APRIL 23, 1959

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Man and Machine

Contents, Page 3

America's Most Complete Line of Self-Protected Bearings

NORMA-HOFFMANN
Sealed Bearings
Give You Dependable Trouble-Free Performance

Metal Shielded Bearing

"Plastiseal" Rubber Sealed Bearing

There's a good reason why Norma-Hoffmann Sealed Bearings give such outstanding performance under all types of operating conditions.

First — the efficient seals, metal, synthetic rubber, or felt, keep grease in . . . keep dirt, dust and other harmful material out. The special seal designs eliminate race distortion, assure dimensional exactness and quiet operation. They simplify mountings . . . speed up assembly.

Second — all Norma-Hoffmann sealed bearings are "factory packed" with a carefully metered quantity of high quality filtered grease . . . grease that is highly resistant to oxidation . . . grease chosen to meet specific operating temperature requirements.

Result — trouble-free performance over long periods without regreasing.

Investigate Norma-Hoffmann sealed and other bearings for your equipment. Write for engineering assistance and catalog.

Circle 401 on Page 19

Special Seal Design PLUS the right grease for the application insures against dry bearings.

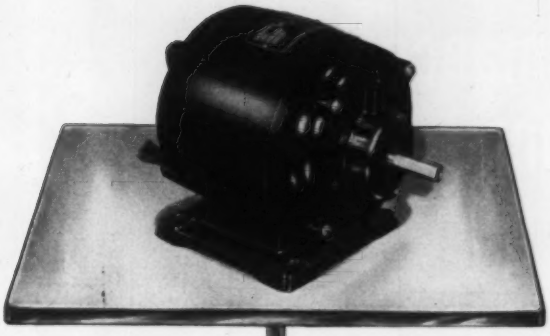
precision ball, roller & thrust bearings

NORMA-HOFFMANN

BEARINGS CORPORATION • STAMFORD, CONN.

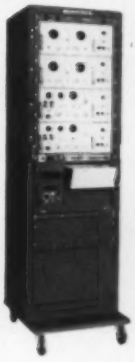
founded 1911

FIELD OFFICES: Philadelphia • Chicago • Cincinnati • Cleveland • Dallas • Denver • Detroit • Kansas City • Los Angeles • San Francisco • Seattle



BODINE MOTORS
In Leading Products . . .

Sanborn Oscillographic Recording Instruments



The element of time is very important in recording electrical and physical properties . . . and this is one of the reasons that Bodine synchronous motors are used to power Sanborn Oscillographic Recording Instruments. These units can operate at nine different paper chart speeds, and the motor that powers the chart moving mechanism must respond quickly, and be capable of operating at any of the pre-determined constant speeds. Over the years Bodine motors have met Sanborn's requirements for constant speed, minimum noise, uniform performance and long life.

Esterline-Angus Recorders

To provide a complete record of what happens during a power failure, Esterline-Angus developed an external motor attachment for their recorders. When a power outage occurs, the Bodine motor driven attachment takes over and increases chart speed to ¾" per second to record these split-second occurrences.

The ability to start fast, accurately maintain the necessary speed and operate quietly are the main motor requirements. It was also necessary that both AC and DC motors have the same mounting dimensions. Esterline-Angus found that Bodine motors made their external drive less cumbersome.

BODINE ELECTRIC CO.
2258 W. OHIO ST., CHICAGO 12

How to make motors last longer

Proper maintenance is your best insurance for obtaining good service and long life from fractional hp electric motors.

Inspect your motors regularly. Twice a year inspect bearings, cutouts and other wearing parts. Be sure dirt and dust does not interfere with ventilation, or clog moving parts.

Check load condition. Additional friction sometimes develops gradually in the machine your motor must drive, and thus imposes an overload. Watch motor temperature. Protect your motors with properly rated fuses or overload cutouts.

Replace worn brushes. Inspect brushes regularly. Whenever a brush is removed for inspection, be sure it is replaced in same axial position and NOT turned around in the brush holder. Otherwise excessive sparking and power loss will result.

Keep commutators clean. Use clean, dry cloth or one moistened with carbon tetrachloride to remove dust and oil. If necessary use No. 0000 or finer sandpaper.

Watch future Bodine ads for additional maintenance suggestions.

Free subscription to "The Motorgram"

Ask that your name be added to the circulation list to receive "The Motorgram." A bi-monthly publication, it discusses the design and application of fractional horsepower motors.

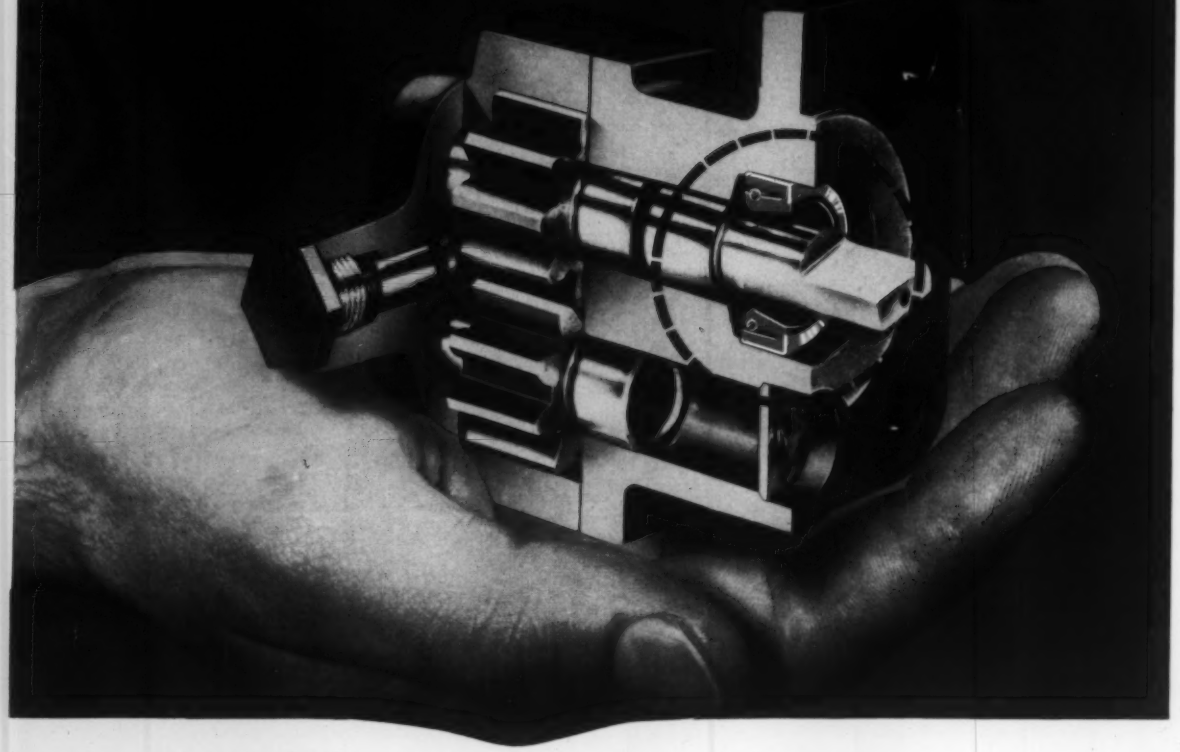
BODINE
fractional / horsepower
MOTORS

BODINE ...the power behind the leading products

12 to 16 week delivery on fractional horsepower motors
265 different stock types and sizes ready for fast shipment!

Circle 404 on Page 19

Champion performance in a fist-sized pump...sealed by C/R



THE PROBLEM:

To seal a rotary pump handling a wide range of fluid viscosities, pressures and temperatures

These pumps are performing dependably in hundreds of different hydraulic applications. They handle any fluid with lubricating qualities . . . deliver up to 180 gph, and maintain high volumetric efficiency even with low viscosity fluids. This particular pump also carries Underwriters' Laboratories approval for use in oil burners. For dependable sealing, C/R's Type HMS Oil Seal was chosen. It performs effectively from 28" Hg to 5 psi, and from 50 to 8000 rpm. This is only one of the thousands of ways in which C/R Oil Seals and engineering are solving difficult sealing problems throughout industry. C/R engineers can help you, too—especially where critical conditions exist. A letter or telephone call will get them started for you. Write for your copy of the catalog, "C/R OIL SEALS."

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

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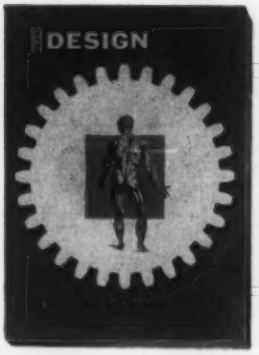
OIL SEAL C/R DIVISION

CHICAGO RAWHIDE



Front Cover: The two elements of man and machine make up the science of human-factors engineering, discussed in a new series by John Vandenberg on Page 108. Artist George Farnsworth has epitomized this concept with a figure by Vesalius and a gear. More about this cover on Page 109.

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Write for Bulletin TB-347, The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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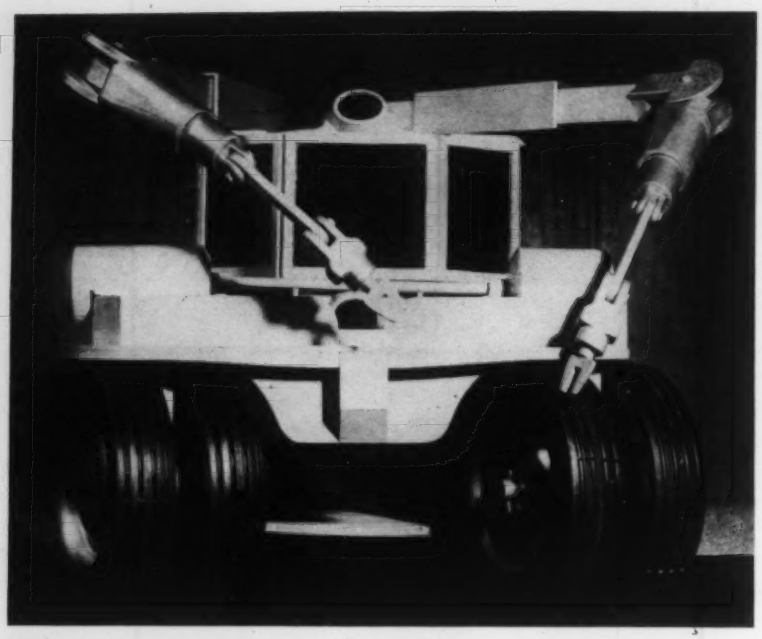
Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges —in carbon, alloy and stainless steels and special metals.



ATOMIC BEETLE, so called by General Electric Co., is a manned, self-propelled vehicle for remote servicing of nuclear aircraft powerplants. It contains 75,000 lb of lead and steel and has 22-in. thick windows that provide visibility equal to that of a modern car windshield. Mechanical manipulators are 16 ft long and are attached to cab which can be elevated 15 ft; rotated 360 deg. Manipulator "hands" grip with a force of 200 lb and are equipped with electrical outlets for power tools. Powerplant is a 750-hp engine which provides 10-mph speed and 80,000 lb of drawbar pull. Each pair of wheels is independently powered and steered. Beetle is capable of doing all phases of aircraft-powerplant maintenance.

The Long and Short of It—Engineers Discuss Antennas

NEW YORK—Radar antennas that will detect enemy missiles up to 3000 miles away and the effect of low pressures on guided missile antennas highlighted the antenna session at the recently held IRE conference. Antennas for the 3000-mile range, normally large and unwieldy, would be radically designed by J. M. Flaherty and E. Kadah of Westinghouse by having the beam electrically moved back and forth while the antenna remains in fixed position. Because the low pressures of outer space results in premature antenna breakdowns on guided missiles, three engineers of the Stanford Research Institute described steps being taken to make the antennas more serviceable at high altitudes.

Other reported developments included a novel antenna for mobile radio relay operation, developed by the Army Signal Corps and a lightweight, high-gain antenna developed by the Airborne Instrument labs. The Signal Corps antenna, a "double rhombic," has low wind drag and light weight, and can be easily assembled and disassembled. The Airborne antenna is a high-gain type for very-high-frequency operation. It is very long and is designed for mounting on four telephone poles.

Color Coating for Stainless Withstands Severe Forming

Applicable Also to Steels, Slated for Range of Colors

NEW YORK—A recently developed process for coloring stainless steel permits severely forming large parts after coloring without impairing the surface. The Permyron process, developed for commercial use by Electro Metallurgical Co., Div. of Union Carbide Corp., also shows promise for the coloring of aluminum, plain carbon steels, and other metals. Although only black is now being produced commercially, the coating will ultimately be available in a range of colors.

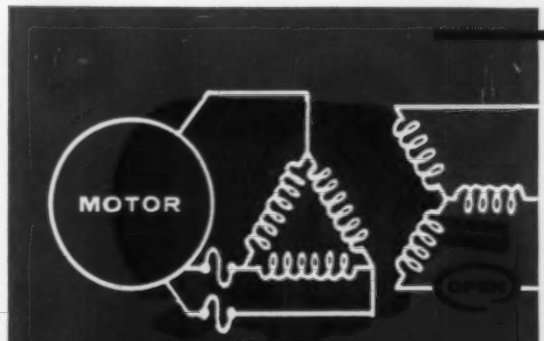
The process presents new possibilities for the use of metals in such fields as automobiles, appliances, miscellaneous consumer products such as household furniture, photographic equipment, sporting goods and toys, barbed wire, and aircraft. Use of the coating is forecast on magnesium and other light-metal members of aircraft, on home appliances, and automotive trims.

Construction of Union Carbide's new 52-story building spurred development of the Permyron process. Because architects specified black surfaces to highlight the stainless steel building, the Electromet Div., stainless steel specialists, developed the coating process. The result is a tough, low-cost coating, that weighs only 500 lb total when applied to the specified 300,000 sq ft of building panels.

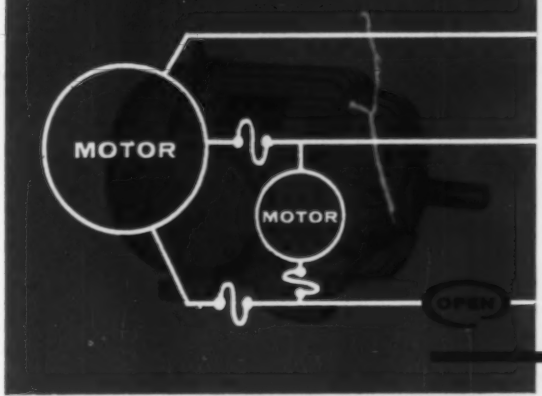
Colored stainless steel produced by the process is said to have many advantages over porcelain enameling. It is flexible and can be deep-drawn and bent after coloring without cracking or crazing.

Basically, the Permyron process involves a chemical reaction, achieved by applying the proper pigment in a suitable vehicle to specially prepared surfaces by such methods as spraying or roller coating, and processing under controlled

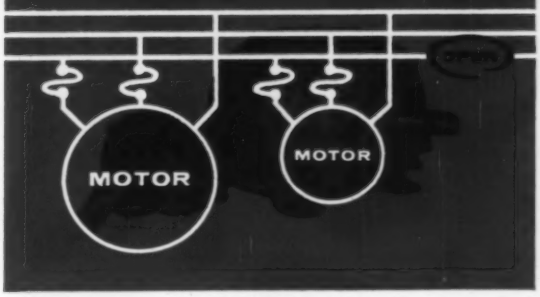
Three-Coil Overload Protection Would Have Prevented These Motor Burn-outs



MOTOR No. 1. Even though this three-phase motor was equipped with a 2-coil overload relay, the motor burned out . . . and here's why. Like the vast majority of three-phase motors in use today, this motor took its power from a wye-delta transformer; and an open phase condition in the transformer primary caused one high and two low motor currents. The 2-coil overload relay could not save this motor because the high current was in the unprotected line. Why gamble with a motor burn-out? Insist upon 3-coil overload relays for all your three-phase motors . . . the only dependable overload protection for all open phase conditions.

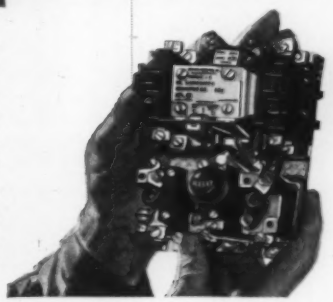


MOTOR No. 2. This three-phase motor was operating at 70% full load with a 40% loaded single phase motor connected in parallel when one of the incoming power lines opened. Once again the 2-coil overload relay failed to detect any trouble. However the motor current in the winding without a thermal element rose to 152% full load current, while the current in the phases with the 2-element relay did not reach tripping value. This caused permanent damage to the motor winding. This motor could have been saved with full three-phase overload protection. Be sure your three-phase motors are completely protected from the hazards of all open phase conditions with dependable 3-coil overload relays.



MOTOR No. 3. This 1 Hp, three-phase motor was working in parallel with a 10 Hp, three-phase motor when one of the incoming power lines opened. While the 10 Hp motor was not adversely affected by this circuit unbalance, the motor current in one line of the 1 Hp motor reached 140% full load current resulting in a burned out winding. As in the other examples, the 1 Hp motor's 2-coil overload relay proved ineffective because the overload occurred in the one line left unprotected. Don't let this happen to your motors. Insist upon 3-coil overload relays for every three-phase motor, large or small . . . only 3-coil overload relays provide dependable open phase protection under all operating conditions.

Cutler-Hammer Three-Star Motor Control offers 3-coil overload relays in all standard starter constructions and enclosures. For immediate delivery see your nearby Authorized Cutler-Hammer Distributor. Machine designers and panelbuilders, open type Cutler-Hammer Three-Star Motor Control with 3-coil overload relays require no more space than starters with only 2-coil overload relays. CUTLER-HAMMER Inc., 1310 St. Paul Ave., Milwaukee 1, Wis., *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.



CUTLER-HAMMER
☆ ☆ ☆
MOTOR CONTROL
C-H

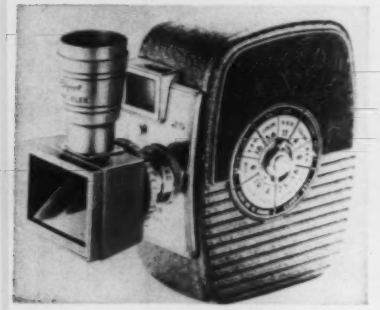
Circle 407 on Page 19

conditions of temperature and atmosphere. The resultant coating is durable and can withstand forming and fabrication temperatures of the order of 650 to 700 F.

Reflex Viewer for Camera Cuts Parallax in Close-Ups

ROCHESTER, N. Y.—A reflex viewer attaches to 8 and 16-mm camera lenses for use in close-up conditions where camera parallax, cramped quarters, and the need for a studied composition require an auxiliary, sighting-framing device.

The Elgeet Cineflex permits a periscope, ground-glass view of the

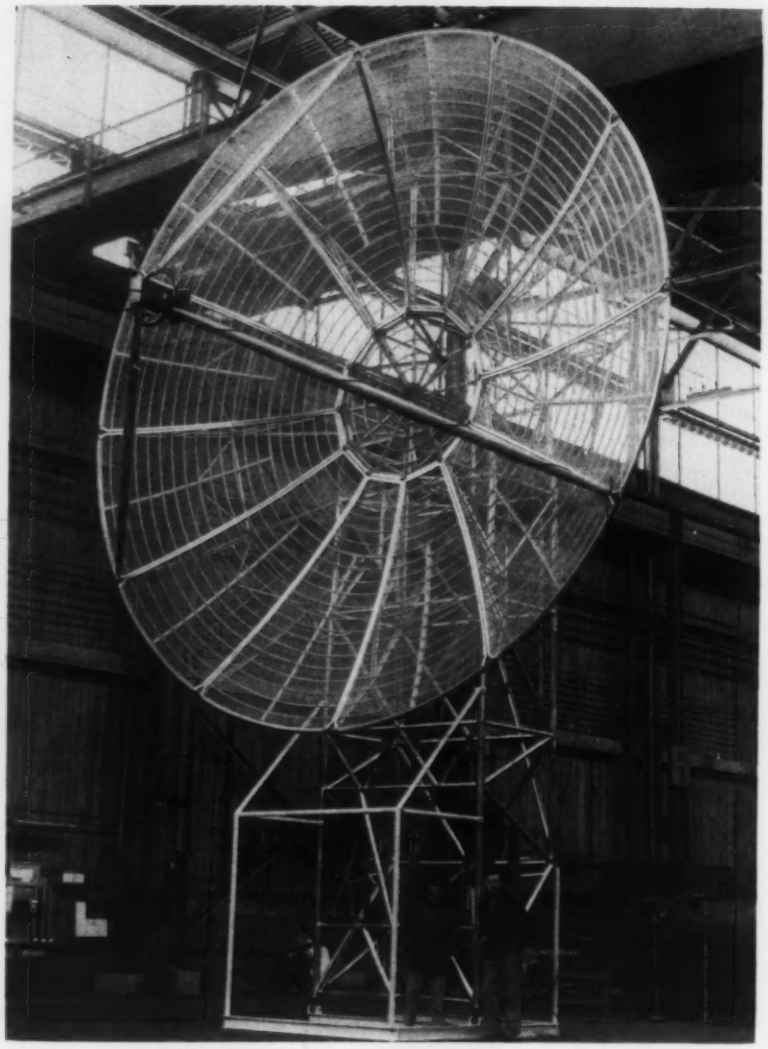


movie subject before, after, and during filming. Heart of the unit is a two-way mirror and the optics necessary to produce the reflex image.

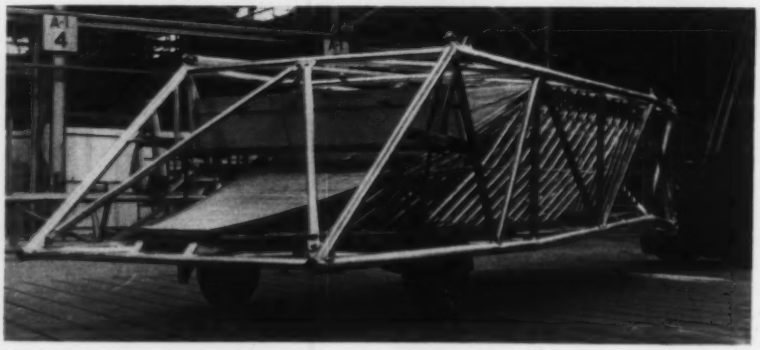
The movie camera's own lens focuses independently of the viewer. Major advantage of the unit is to provide accurate close-up filming of flowers, portraits, and such common movie elements as tight framings of hands, letters, and clocks.

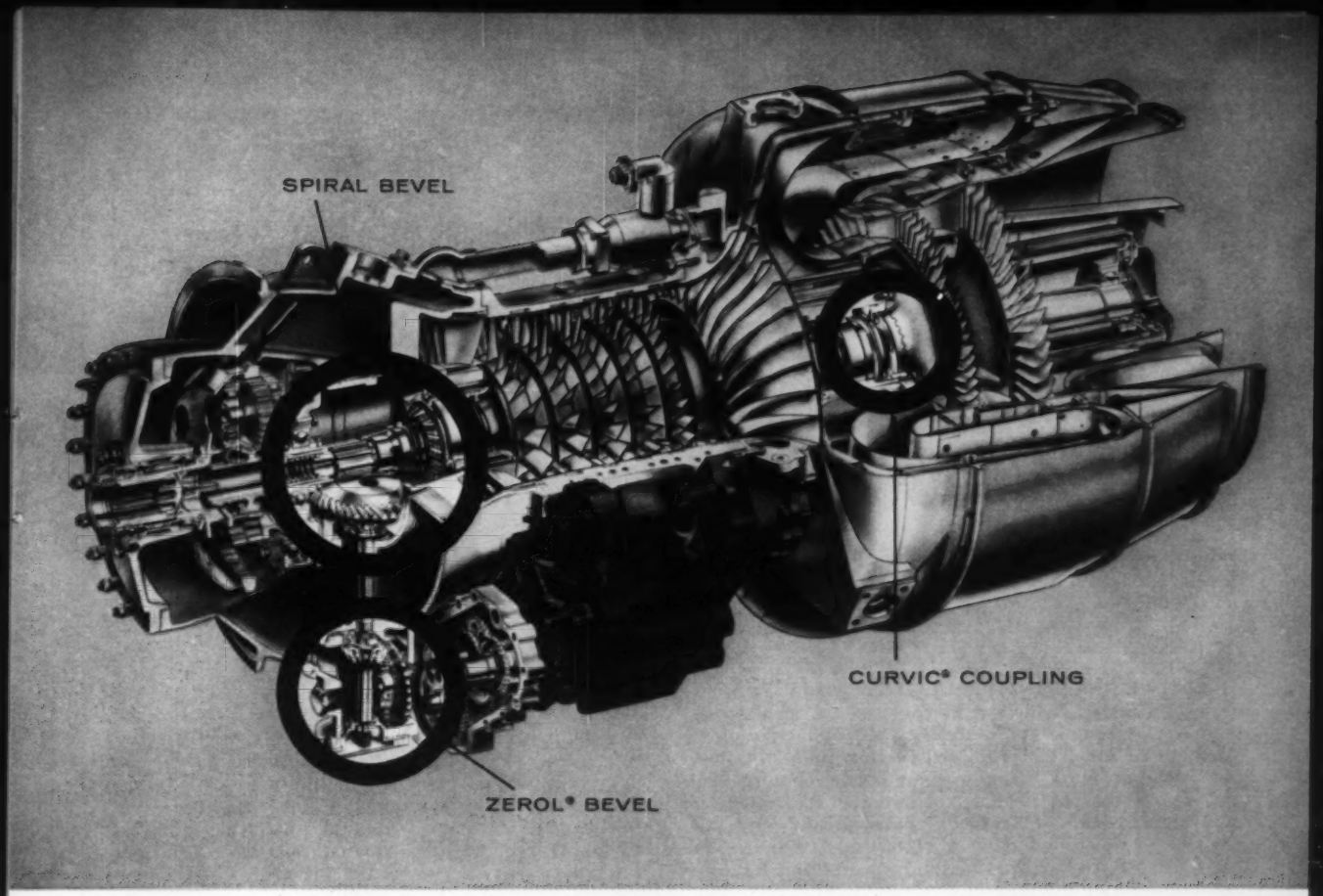
To cut radar costs, an automatic control system would reduce transmitter power when favorable propagation conditions make lower power practical. Suggested by L. P. Yeh of Westinghouse Electric Corp., this is expected to reduce fuel supply problems in the northern radar networks, as well as reducing interference with other communications networks.

The new system would constantly "listen" to signals from another station in the system, thus deciding when less power would be satisfactory and automatically making the necessary adjustments.



TWELVE SECTIONS bolted to a center piece form the parabolic reflector of this collapsible, mobile, radar antenna by D. S. Kennedy & Co., Cohasset, Mass. Reflecting surface, truss-reinforced, is made of aluminum mesh having openings from $\frac{3}{8}$ to $\frac{7}{8}$ in. Beam axis orientation may be measured to an accuracy of 0.2 deg; does not deviate more than $\frac{1}{2}$ deg in worst conditions of wind, ice, and temperature. Structure is towed to point of use on its own trailer. Thus collapsed, assembly is 30 ft long, 8 ft wide, 8 ft high, weighs 330 lb. Wheels retract when frame becomes tower. Mobility and compactness substantially extend choice of operating sites.





How to get *engineering assistance* on gears and couplings like these

Gleason engineers are always ready to help you work out any problems involving bevel gears and couplings.

Such assistance came to the makers of this turbine in four different areas:

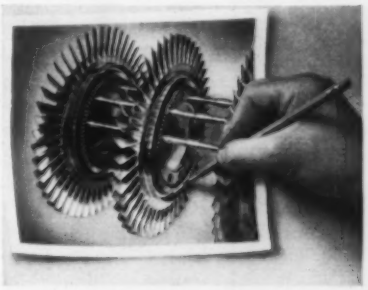
First, they naturally wanted components which met the designated theoretical requirements of the turbine. Our engineers helped determine the types and sizes of the gears and Curvic® coupling as well as such details as axial thrust and radial load.

Second, they wanted compactness. The angular drives made possible by the spiral bevel and Zerol® bevel systems helped materially to fit the drive into the limitations set by the turbine's over-all dimensions.

Third, they wanted low costs. The machines and methods developed by Gleason engineers assure the lowest possible costs for both gears and couplings whether made in small or large quantities. The Curvic coupling design inherently cuts coupling costs; see picture at right.

Fourth, the makers wanted extreme reliability. The success of the gears and couplings in this respect is witnessed by the fact that this turbine is used by six major aircraft companies and has recorded more hours of flying time than any other turbine in its power class.

If you would like to discuss your bevel gear or coupling application with a Gleason representative, please contact us.



With Curvic couplings complex machine parts can be made in several small units, reducing machining time, simplifying final assembly, and cutting over-all manufacturing costs.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

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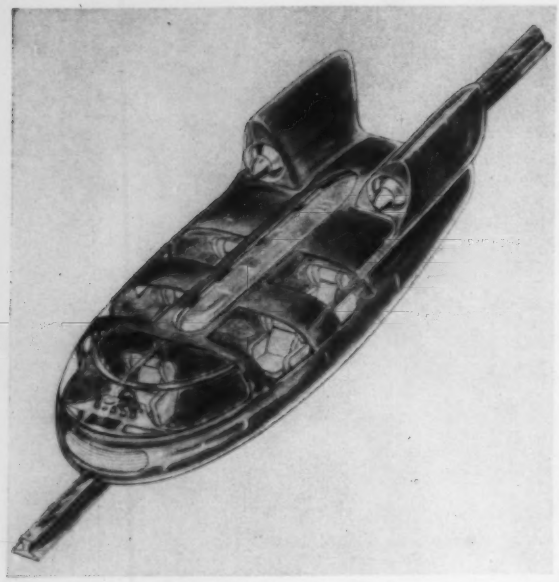
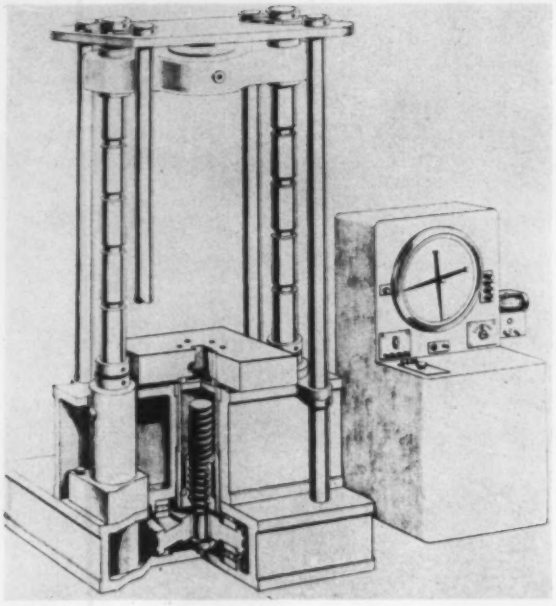


LEVAPADS AND GYROSCOPES would position Ford's Glideair vehicle a fraction of an inch above the rail, where it could easily speed 400 mph on a cushion of air. This is an artist's concept of the new vehicle, but Ford has a working model. Future versions will use gas turbines or turbojets for levitation and propulsion — "levapads" have already been designed to fit around rails. About 50 hp is required to levitate 1 ton of vehicle weight; 40 additional horsepower to move it 100 mph. Glideair has high power-to-weight ratio because it encounters no road friction and little aerodynamic drag—no wings or tail structure.



LARGEST MECHANICAL TESTING MACHINE ever built is claimed for this 150,000-lb unit designed by Baldwin-Lima-Hamilton Corp. The machine can apply tension, compression, or alternating loads to a test specimen. Cutaway drawing shows the basic straining mechanism — a single, preloaded ball and screw which replaces previous square-thread screws and permits heavy straining without backlash. Notched columns are the working columns. Table is connected to a ram assembly which is attached to the ball-screw nut. Rotation of bull gear turns screw, then the ball nut.

Confetti Dropped by Rocket Gages High-Altitude Winds

Assures Deadlier Missile Shots, Gives Clues on Weather to Come

WASHINGTON—A new method of plotting upper-atmosphere winds, devised by scientists at the U. S. Army Signal Engineering Laboratories at Ft. Monmouth, employs small Loki II rockets carrying packets of confetti-like aluminum chaff. At a pretimed altitude, a cloud of chaff is released and tracked by radar to produce a fast and accurate wind profile. The Loki dart, which carries the chaff, is 40 in. long. Its rocket engine, which drops off, is 5 ft long.

The rockets reach an altitude of 283,000 ft—about 54 mi—and the light chaff has been swept along at 200 mph by the winds. Recent tests show this method can give an unbroken map of wind speed and direction—the first time in history this has been possible at such altitudes—and will facilitate weather forecasting and aiming of ICBMs.

Use of Loki rockets to sound the way for high-altitude missiles is cheaper, easier, and faster than all previous methods of measuring high level winds, according to the Army. Ground launching platforms are mobile, and in combat could be moved with the Army's artillery and missile batteries.

In similar tests, Stanford Research Institute has fired tiny, man-made meteors into space as an aid to research in radio communications and propagation. The meteors are actually tiny fragments of aluminum from linings of specially-shaped, hollow explosive charges—blasted from an Aerobee rocket.

On being detonated, the explosive forces the aluminum linings out of the charges, reshaping the linings into thin jets of aluminum moving at great speed. The resulting velocity is greater at any given point along the jets than at any point following. Consequently, the aluminum in each jet finally becomes so elongated that it breaks apart into separate meteors. Photographs of the firings indicate that the meteors flashed into outer space at speeds of more than 40,000 mph.

Imparting such tremendous ve-

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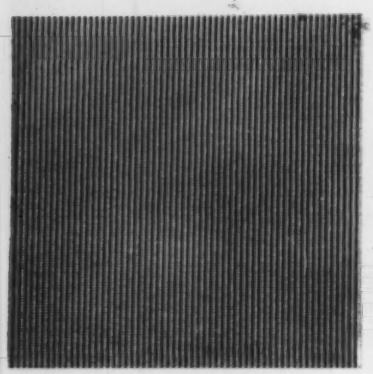
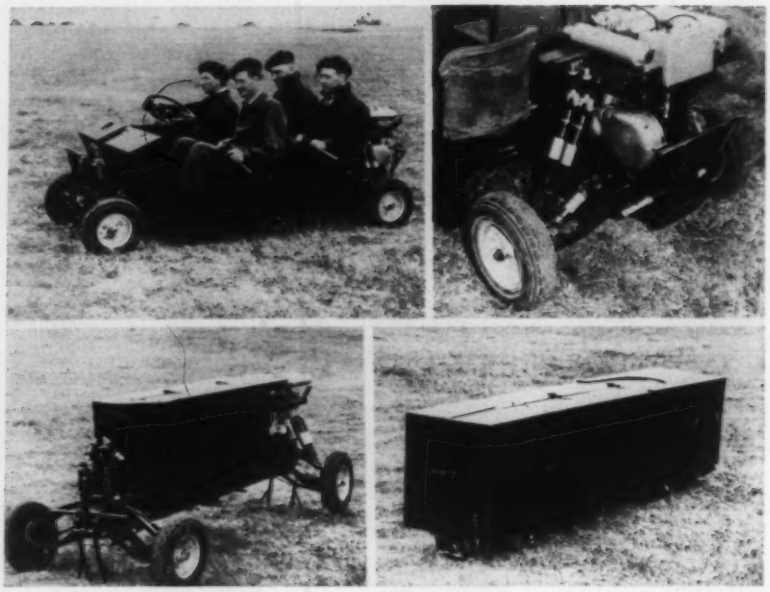
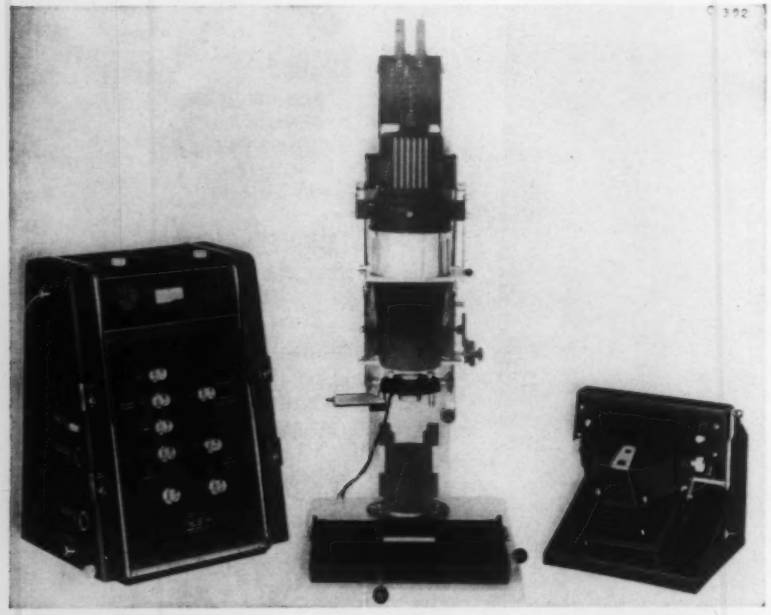
locity to objects in the upper atmosphere has significance for research in directions other than radio communications and upper atmosphere physics. It has been suggested that high-velocity pellets could be useful as antimissile weapons.



BRILLIANT MILLIONS of tiny, lens-shaped particles on projector screen permit film viewing in fully lighted room. Designed by the Universal Screen Co., the optical system is formed on metalized Mylar.



BOX-CAR is unfolded in one minute to carry four men, or a driver and 560 lb cargo. It travels cross-country, up to 60 mph on roads, fords streams 12 in. deep. Folded, it forms 700-lb box 9 ft long, can be parachuted from aircraft. Boxes can be stacked one upon another without bracing. Called Harrier, the truck is made by Hunting Percival Aircraft Ltd., England, using lightweight materials, aircraft techniques.



In tricolor computing system, principal unit is the switchboard, which resembles a radio control panel. Information is fed into unit by dialing negative size, magnification ratio, preferred density, and estimated color corrections. The board then computes exposure times for the three primary-color filters. Electric-motor driven filter turret, placed before the enlarger lens, is automatically controlled by impulses from the switchboard. A photocell mounted on the turret measures negative density. Color comparator contains viewer to preview final print and furnishes a numerical evaluation which is then fed back into the computer.

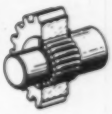
Computer in Darkroom Simplifies Color Printing

Accurate Numerical Data Determine Print Exposure

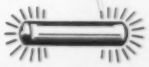
LONG ISLAND CITY, N. Y.—An automatic color computer simplifies the production of custom-quality, color prints. The new system eliminates the present cut-and-try method for determining color-filter exposures. Instead, it obtains an accurate numerical evaluation for computer purposes, and then actuates three color filters in a timed sequence of exposures.

With the Tricolor Computer, designed by Simmon Bros. Inc., a single sheet of 8 x 10-in. type C material is first exposed in four sections with a different color negative on each section. These single test prints, analyzed in the unit's color comparator, and with negatives measured on the unit's photoelectric cell, provide complete information and a numerical evaluation to the computer. The computer then determines exposure ratios for all degrees of enlargement or preferences for previewed color correc-

Full complement of small diameter rollers insures maximum number of contact lines in load zone for high radial capacity in minimum space.



Mounted without races between hardened shaft and hardened housing (RC-60 recommended), Torrington Needle Rollers allow largest possible shaft diameters.



Carefully hardened, ground and lapped high carbon chrome steel makes each Torrington Needle Roller a precision part for long life performance.

Close tolerances are assured by stringent quality controls. Standard OD tolerance is .0002", but Torrington Needle Rollers can be supplied with tolerance of .00005". Tolerance on length depends on end shape.

Fine finish reduces friction to a minimum. Torrington Needle Rollers are usually polished to 4-6 rms, but finishes as fine as 1-3 are available on special order.

Now you can get highest capacity at lowest cost with Torrington Needle Rollers

A hardened shaft, a hardened housing, and precision Torrington Needle Rollers provide the most economical, highest capacity antifriction assembly you can obtain.

Six roller end shapes permit design flexibility whether the requirement be maximum effective roller length, proper fillet clearances or greater lip retainment. Torrington Needle Rollers are available in a complete line meeting SAE and AFBMA specifications. Torrington standards for material, heat treat, tolerance and finish of Needle Rollers are the highest in the industry.

Operating results with Needle Rollers depend on careful design of mating parts. Torrington's Engineering Department, with extensive experience in Needle Roller application, will be glad to give you technical advice on your needs. *The Torrington Company,* Torrington, Conn.—and South Bend 21, Ind.

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Circle 410 on Page 19

tions; sets each color exposure.

From the small test print, the factors of negative density, degree of enlargement and color balance are correlated automatically and electrically. The computer then actuates three color filters in a correctly timed sequence of exposures to result in what is reportedly, with only rare exceptions, a perfect large color print.

PORT-A-PUNCH, a pocket-size card punch for on-the-spot data recording, is one of IBM's less complicated developments. To use the new device, a prescored card is inserted beneath the clear plastic template, holes are punched with a special punching tool, and the card is ready for machine use

Steps into Space

Lunar probes, in the lexicon of the Dept. of Defense, will be undertaken by the Army Ballistic Missile Agency and the Air Force Ballistic Div. In everyday words, this means that the Army will proceed with a program to launch one and possibly two small, unmanned vehicles to explore the moon, while the Air Force program authorizes the launching of three such vehicles. No timetable has been set for successful completion of efforts.

• • •

Explorer III carries two "dipole" antennas in place of four whip antennas protruding from Explorer I. Two metal halves of Explorer III, separated by insulating ring, act as antennas. Vibrating whip antennas of Explorer I have converted its original bullet-like path into a tumbling frankfurter motion. This varies satellite's position with respect to the sun, leaves delicate mechanisms open to hazards of melting or freezing.

• • •

No bomb for moon is one of many intriguing judgments made by President Eisenhower's Space Advisory Committee in their report, *Introduction to Outer Space*. The group, headed by Dr. James R. Killian Jr., opposed contamination of the moon by an earth-sent nuclear weapon, citing as one argument the scientific hypothesis that small particles with the properties of life could have drifted onto the moon from outer space. Prepared for the nontechnical reader, the report describes space possibilities, slices the line between fact and fancy.

First fully instrumented satellite of the Vanguard series planned for launching during 1958 will have 20 in. diam and weigh approximately 21½ lb. According to the Dept. of Defense, the skin will be made of a magnesium alloy, coated with gold, chromium, a layer of silicon monoxide, aluminum, and another coating of silicon monoxide.

These coatings are designed to provide optimum reflectivity and absorption in the visible and infrared portions of the electromagnetic spectrum. Instrumentation in this satellite will be housed in an internal cylinder and weigh approximately 10¾ lb, 8 lb of which will be chemical batteries.

Instrumentation in the internal "package" or on the shell of the satellite will include two ionization chambers, a solar aspect cell, erosion gages, a cadmium sulfide cell for erosion studies, micrometeor microphones, thermistors, a Minitrack radio transmitter, a telemetry system, and ultraviolet radiation (Lyman alpha) memory storage units.

• • •

Communications via satellites could be one of the earlier rewards to be reaped from space ventures. Because high-frequency radio signals cannot be reliably bent around the world, several satellites could be used as high flying radio relay stations. TV signals, for example, beamed from the earth, could be bounced against one and possibly two of the satellites, to reach any point on the globe.

Army Relies On Past Experience For Rapid Missile Progress

Nothing Succeeds Like A Well-Tested Fuel Pump

WASHINGTON — "Conservation of know how" is responsible for the Army's rapid progress in missile development, according to Major General John P. Daley, Army R & D chief.

Speaking before a recent meeting of the Air Force Association, the General minced few words in praising the Army's successful Redstone, Jupiter IRBM, and Jupiter-C satellite vehicles, and in tracing their distinguished development.

Said the General, "The Redstone has achieved a truly spectacular record of reliability and successful performance. If we consider the development history of the German V-2, technical predecessor of the Redstone, we are reminded that over 3000 test firings were made in order to achieve a reliability . . . on the order of 70 per cent. The Redstone, with only a fraction of these firings, has already achieved substantially greater reliability.

Jupiter development is progressing with similar economy and time saving, simply by relying on well-tested hardware and utilizing "to the utmost, hard-won solutions from previous programs and firings."

Past experience has proven invaluable in design concept as well as in development, according to General Daley. Reviewing German V-2 development, he recalled that at no time was a V-2 launching ever thwarted by Allied action, even though the Allies had complete control of the air. German Army mobile teams were able to move into any convenient village or grove, set up and fire a group of three missiles, and move out within a few hours. The only complete failures in the entire V-2 program were the massive fixed concrete bunkers with their missile-launching pads that were built by Hitler against the best

advice of his military commanders. These proved absolutely useless in the face of repeated Allied bombing.

The Jupiter was conceived as a mobile system. It has features incorporated in its guidance system, erector, and launcher, which permit rapid movement between tactical firing positions, unidentifiable by the enemy. With this concept comes the advantage of "political mobility." The missile can be set up without months of negotiation over months of concrete construction.

By adhering to the "conservation of know-how" principle, General Daley could report only one major oversight in progressing from V-2 to Redstone to Jupiter; the Army failed to have on hand enough light blue paint for the Jupiter.

Machine Design Appoints Assistant Editor

CLEVELAND — James A. Parks has joined the staff of MACHINE DESIGN as an assistant editor.

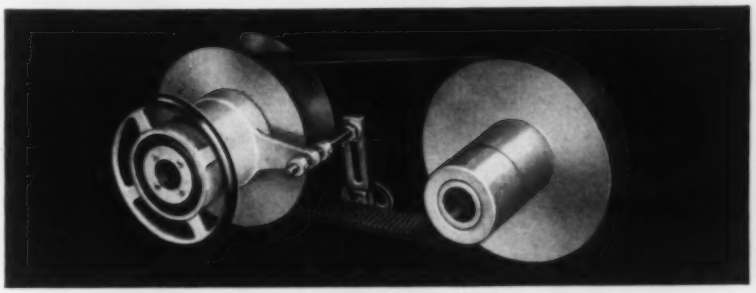
A graduate of Ohio Northern University, Ada, Ohio, Mr. Parks holds a B. S. degree in civil engineering.

James A. Parks

He was a development engineer in the research and development section of Pesco Products Div., Borg-Warner Corp., for about a year prior to joining MACHINE DESIGN.

His present duties include preparation of the Engineer's Library and editing of technical articles.

DIRECTLY APPLY VARIABLE SPEEDS



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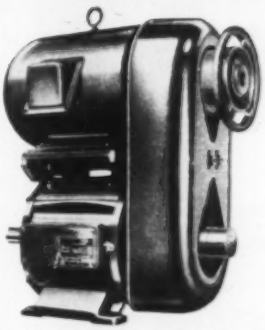
COMBINATION PULLEYS



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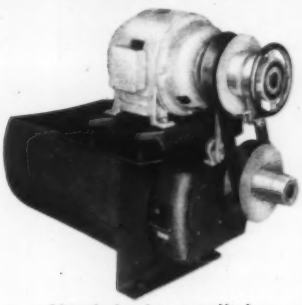
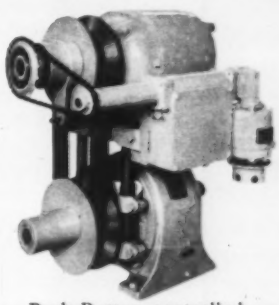
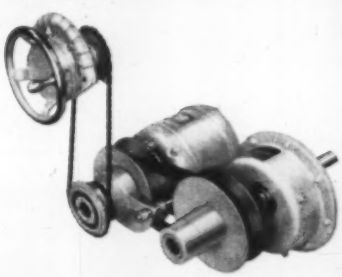


Handwheel controlled Medor Screw Conveyor



Push Button controlled Foote Vari-Mount Reducer



Chain Shifter controlled Falk shaft-mounted Reducer

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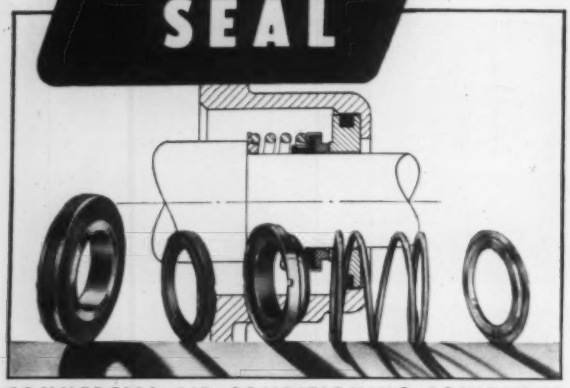
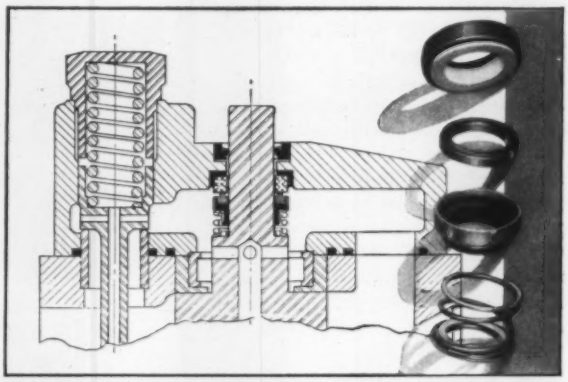


COMMERCIAL AIR CONDITIONING EQUIPMENT



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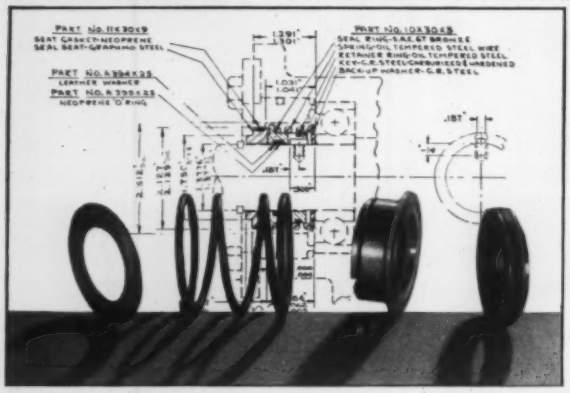
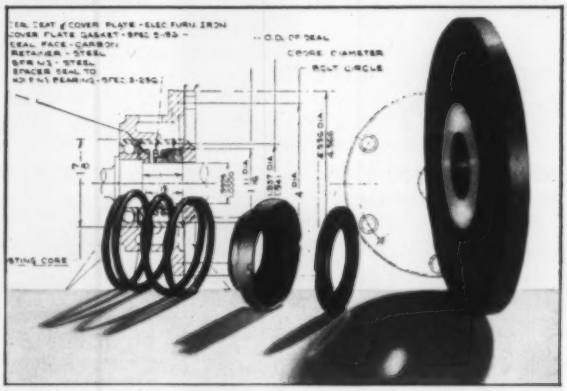


AUTOMOBILE AIR CONDITIONING COMPRESSORS



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417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
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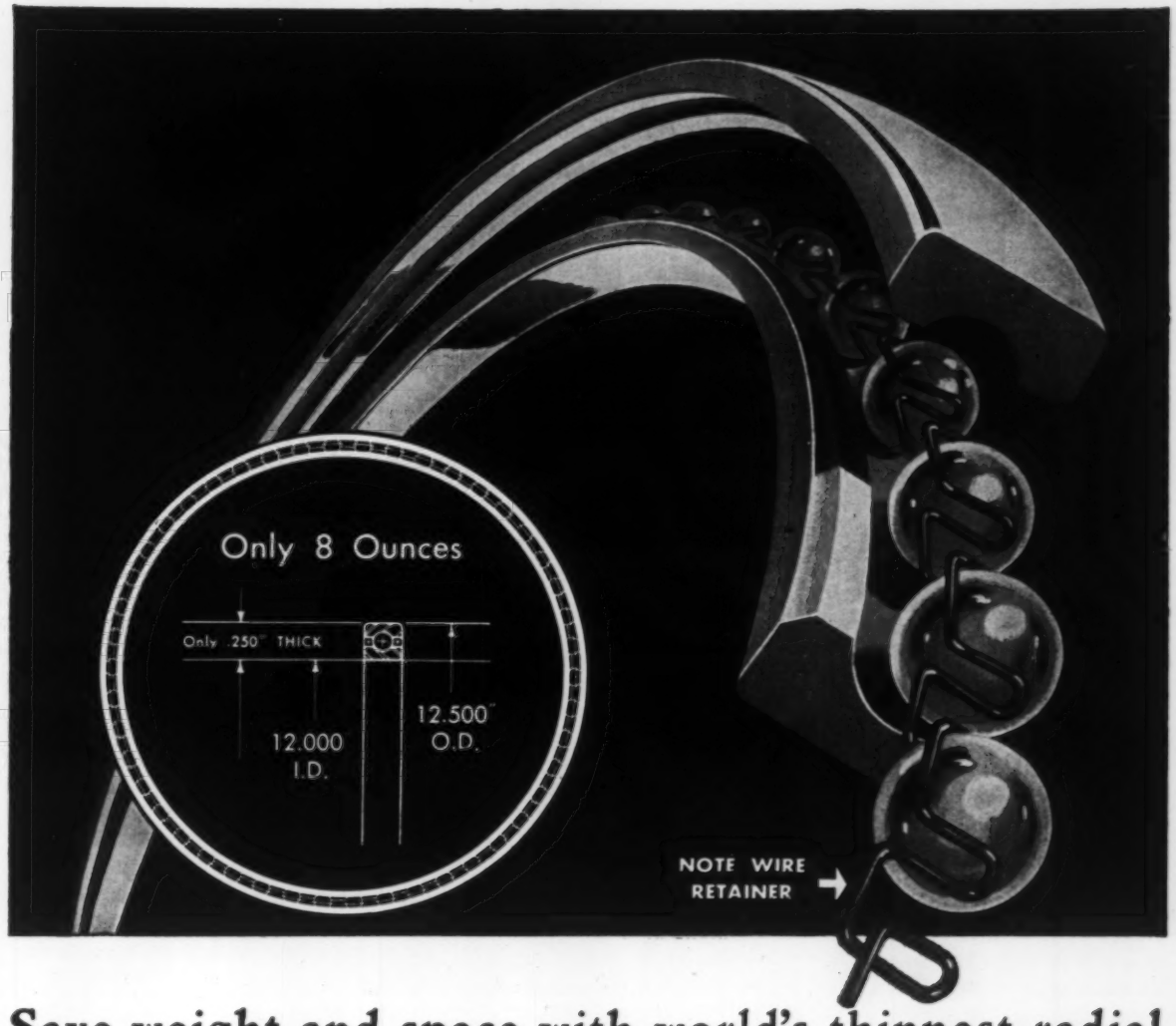


Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561

All types of ball and roller bearings — 4" to 120" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Needle Roller • Ball Radial • Ball Thrust Bearings.

Filling the gap between desk calculator and large-scale computing facilities is the job for . . .

DESK-SIZE DIGITAL COMPUTERS

ASSUMING THE BURDEN of repetitious computation, computing equipment used to be an expensive advantage limited only to engineering departments in the largest companies. Now a selection of small, general-purpose, digital computers speed product development and reduce engineering costs for large and small engineering groups alike. With no aversion to work, these relatively inexpensive machines tackle tough analytical problems and give engineering personnel more time for creative engineering. Cost is in the $35,000 to $50,000 range.

Small and efficient, the average desk-size computer operates from a standard wall outlet and requires no more power than a toaster. Air conditioning, needed for large computers, is seldom required and overhaul of office or laboratory space is not necessary. Mobile, the computer can be rolled easily from one location to another.

Simple to program, these small machines don't usually require special operators or programming experts. Some organizations prefer to have one or more staff members in charge of programming, but many experienced users point to the virtues in having all members of the engineering department familiar with programming methods:

- Capacity of each engineer—and the entire engineering department—is increased without need of additional personnel.
- Engineers working on a particular problem are usually better equipped than an "outsider" to interpret the problem at hand, which adds to computer efficiency.
- Programming requires the engineer to think the problem through to a logical conclusion—which often results in a more effective engineer.

All computer makers offer training courses, field representatives, and plentiful supplies of instruction literature. They also provide "canned" programs (subroutines) for a variety of routine arithmetic computation.

Desk-size machines vary in calculating speed, storage capacity, amount and type of input-output equipment, and programming methods.

Calculating speed may vary from 1 to 200 multiplications per second between machines. On many problems, this difference is not important, since calculating speed of the computer is often negligible in total problem-solving time. However, for repetitive problems, with large amounts of data, and where

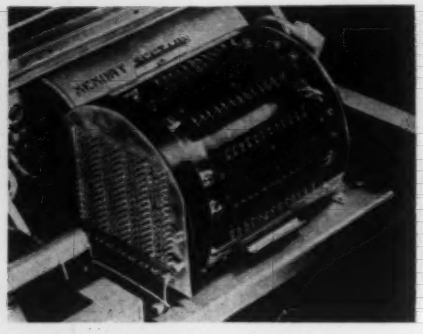
Computing . . . Egyptian Style

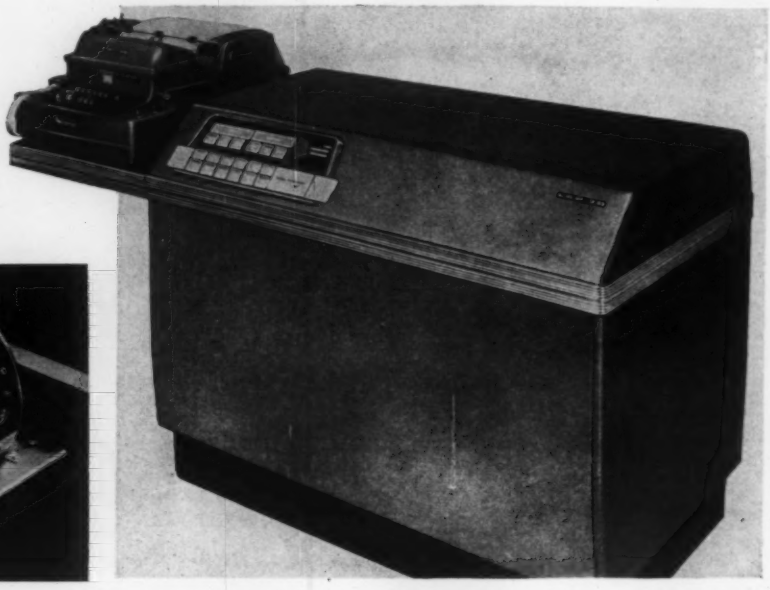
"The Egyptians used an awesome system of numeration which for sheer complexity could hardly be matched. They expressed the digits 1 to 9 by nine staves or vertical lines; 10 was a U or circle; 100 was a coiled rope; 1000 was a lotus blossom; 10,000 a pointed forefinger; 100,000 a tadpole and 1,000,000 was expressed by a man with arms raised high to heaven in amazement. For the number 3,647,543 they had to show: three amazed men, six tadpoles, four pointed forefingers, seven lotus blossoms, five coiled ropes, four hoops, and three staves. Possibly the use of an amazed man to represent 1,000,000 arose from a man trying to portray his feeling after adding tadpoles to forefingers to lotus blossoms to coiled ropes to hoops to staves."

The Story of Calculation, International Business Machines Corp.

Program instructions for Burrough's E101 computer are set up on eight removable pinboards—lightweight frames similar to cribbage boards. Each board contains 16 horizontal rows of tiny holes; each row of holes is an instruction. Pins are placed in the desired holes and the pinboard is inserted in the machine. The machine automatically follows each instruction in sequence unless told to do otherwise. Spare pinboards can be programmed in advance. Paper templates that fit over the boards can be marked to show location of pins on a particular type of problem, and can be saved for future programming of the same type of problem. The manual keyboard and printer, for data input-output, are incorporated in a modified bookkeeping machine.

A variety of accessory equipment is offered with the Bendix G-15 computer. Included are a differential analyzer and magnetic tape auxiliary storage units. The differential analyzer provides simplified programming for solution of linear and nonlinear differential equations. The tape storage units provide a fast external storage medium, with each unit storing up to 300,000 words. Four of these units can be connected to one G-15 computer. The basic G-15, shown at right, has a main drum storage capacity of 2160 words. Electric typewriter, on desk, is used for input, output, and control; *XY* plotter records output of differential analyzer in graphical form, where desired. Several programming methods are offered ranging from a fairly simple method for inexperienced personnel to a system of "microcoding" techniques—a refined programming method for highly experienced users. With microcoding the operator constructs his own commands to meet specific situations; more than 1300 commands are available. Calculating speed of the G-15: Addition (single precision, 7 decimal digits), 540 microseconds; multiplication, 16,700 microseconds. Power requirement: 110 v.





Magnetic-storage drum in Royal McBee's LGP-30 digital computer provides the small machine with a storage capacity equal to some larger computers. This unit has 64 heads, each of which can record 64 words of data and instructions; a bulk memory of 4096 words. The drum rotates at 3600 rpm, making any word accessible in 17 milliseconds. Special coding can reduce access time to 2 milliseconds. Input and output medium is a Flexowriter—an electrically operated typewriter equipped to produce, and to be operated by, punched paper tape. Tape serves as an external medium of storage, as on other machines. When a problem is to be run, input tape is put into the Flexowriter, which feeds information into the computer and simultaneously types a copy for verification. After input tape has been read, the computer takes over control of the Flexowriter to type out answers. The LGP-30 has a simplified command structure of 16 orders which are designated on the Flexowriter by letter. Controls are provided to allow stop-and-go operation giving the operater a step-by-step check on problem progress. After each step, the number held in the accumulator (arithmetic unit), the instruction just executed, and the address of the next instruction are visible on a display oscilloscope. Calculating speed of LGP-30: Add time, 8750 microseconds; multiplication time, 24,000 microseconds. Computer console is 44 in. long, 26 in. wide, 33 in. high, and weighs 800 lb. Power requirement: Conventional 110-v outlet.

programs are thus repetitive, this difference in speed could involve a substantial amount of time.

Magnetic-drum storage devices, used in desk-size machines, provide a fast-access storage medium. Storage capacity between machines varies from 200 to 4000 words. Generally, the machine with a larger internal storage capacity also has a higher calculating speed, since magnetic drums are a much faster storage medium than paper tape or other external mediums.

Input and output equipment is fairly standard among small computers. Most have a keyboard for data and instruction input and overall control of the machine; paper-tape punch and reader for input-output; and high-speed, tape-activated electric typewriter for input-output. Optionally available with some computers. High-speed magnetic tape units for auxiliary storage, photo-electric tape reader, and punch-card equipment.

Difference in programming methods is of particular interest to a potential computer user. Some desk-size machines are similar to larger machines in amount and complexity of programming required. Other machines are quite simple and direct. As a rule, the machine that programs most easily is slower in calculating, since the simpler method requires more operator intervention during the problem-solving process. Amount of operator intervention is the dominating element as far as time is concerned, rather than calculating speed of the computer.

Among the advantages in using desk-size computers, time saving is the most mentioned attribute. One user, Cessna Aircraft Corp., reports that any problem delegated to the small computer for solution has been accomplished "at less cost and time than by any previous method. . . On the highly repetitive type of problem a gain ratio of 100 to 1 has been achieved over ordinary desk calculator or slide rule calculation. Even problems of the 'one shot' variety assigned to the computer for solution show a minimum ratio of 5 to 1. In such cases there is no advantage in trying to optimize the program. All that is necessary is to produce a program that will ar-

Automatic positioning of decimal point (Auto-point Mode) and simple, direct programming are features of IBM's new 610 computer. Single key instructions for square root, combination division-multiplication $[(x/y)Z]$, division, multiplication and addition, enable the operator to enter data into the machine at his own pace. Constant monitoring of progress permits him to check intermediate results; make corrections if necessary. During operation a paper tape may be punched, and since corrections are made as the operator creates his program, no debugging run is required and program tape may be used immediately for other problems of the same type using new input data. The 610 also performs, without supervision, complex computations such as those involved in matrix operations and solution of differential equations. Input devices include manual keyboard, pluggable control panel, program (instruction) tape reader, and data tape reader. Only one control unit may be in control at a time, but control can shift automatically from one unit to another as needs of the problem dictate. Calculating speed of the 610: about 214 additions or subtractions per min; 44 multiplications per min (using Auto-point Mode). Computer console is 53 in. long, 25 in. wide, 40 in. high, and weighs 750 lb. Power requirements: 110 v.

Typical Jobs for the Desk-Size Computer

Engineering:

Aircraft and marine lofting

Load and stress calculations

Wing skin flat pattern

Vibration and energy damping

Bearing load calculations

Cam design

Electric motor design

Plate-to-plate distillation column design

Turbine performance calculations

Research:

Fourier analysis for x-ray diffraction

Eigenvalues of symmetric matrices

Tables of special mathematical functions

Statistics:

Means, variances, standard deviations

Simple, partial and multiple correlation coefficients

Autocorrelation coefficients

Analysis of variance

rive at a correct answer."

Another advantage commonly noted: Analytical simulation made possible by the computer is a cheap tool compared to construction and test of operating units. A typical method of using mathematical analysis to eliminate "cut and try" procedures is reported by the Eclipse-Pioneer Div., Bendix Aviation Corp. The company uses Bendix G-15 computer in designing cams for aircraft electronic equipment. Cam radii are computed with an accuracy to the nearest 0.0001 in., and approximately 1400 radii are found for one cam. Previous manual methods of computation required three to five weeks work on the part of one engineer. By using the computer, the same computation requires about two and a half days. This includes two days of programming; three to four hours of computation and type-out time.

Obtaining optimum design is another advantage cited by users of small computers. Once a program is established, parameters can be readily varied, permitting fast determination of the best possible design.

In determination of the need for a computer, cost is naturally a major factor. The advantages previously listed have a direct bearing on cost economy. As a further estimate: Cost of the computer is about equivalent to the salary of five to seven engineers over a one-year period. If that many engineers, or the equivalent in manhours, are being expended on computation, the small computer might pay for itself in a relatively short period by freeing presonnel for other important projects. —C. E. Wise

MISSILE TRAILER for Navy's solid-fuel Polaris will be used to transport the weapon to launching pad and position it for firing. Completely roadable, the big trans-erector is 60 ft long, 9 ft wide, 8 ft high, and weighs 54,000 lb empty. When raised to vertical position, the trailer is supported by six outriggers which provide a perfect level on the frame before lifting the missile. Design and fabrication of the device were completed in five months by Locomotion Engineering, Inc.

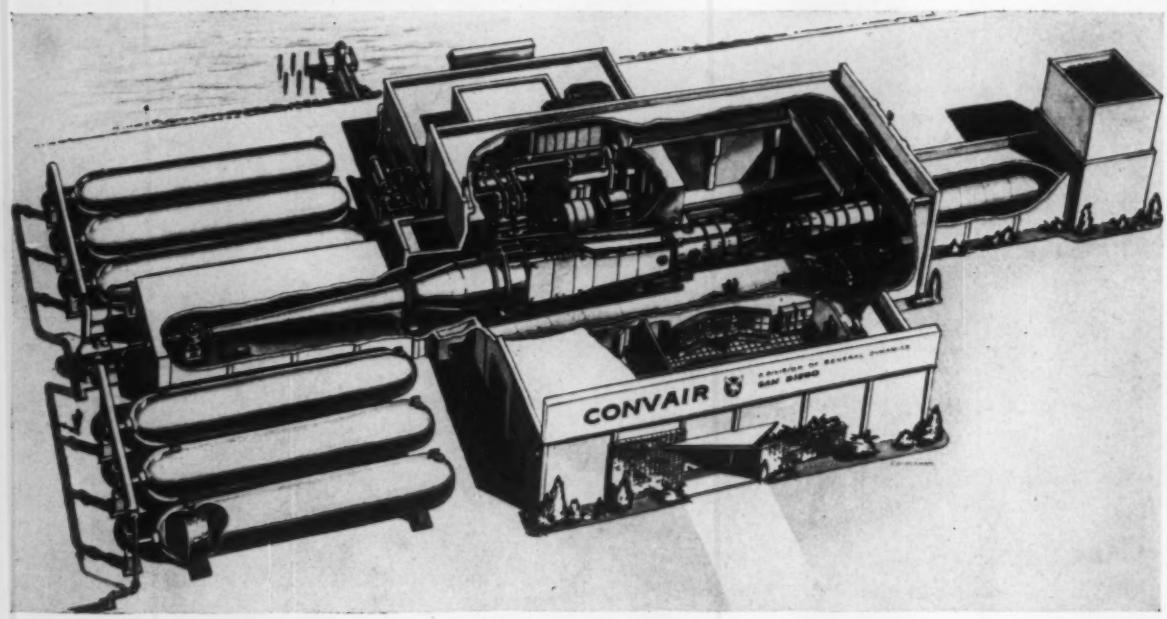
Improved Electrolysis Yields Pure Nickel More Efficiently

NEW YORK — High-quality nickel will be produced more efficiently with a new process announced recently by International Nickel Co.

Main feature of the process is the direct electrolysis of nickel matte, an artificial sulfide. This contrasts with the usual electrorefining methods, including those employed in the nickel industry, in which a metal anode is used.

The new Inco process eliminates high-temperature oxidation and reduction operations, with attendant losses of metals, sulfur, and selenium. Instead, nickel sulfide of low copper content from the Bessemer converter or other source can be cast directly into sulfide anodes and electrolyzed for the production of high-quality nickel.

Another unique feature of the process is that it permits, for the first time in nickel refining, the commercial recovery of elemental sulfur and selenium as valuable by-products, in addition to cobalt and precious metals.



AIR ON TAP, released in short intermittent bursts, provides 3700 mph air speeds in Convair's new Mach 5 wind tunnel. Test runs will average about 30 sec in duration. Tanks, left, store 28,000 cu ft of air, compressed to 600 psi. Compressor storage unit uses three centrifugal pumps driven by an 8000-hp synchronous motor. A comparable continuous-flow tunnel would require 150,000 hp. Airflow through the 4-ft square test chamber is controlled by a 24-in. Rotovalve weighing 12 tons. Keeping air temperature within acceptable limits was a major design problem. Temperature in storage tanks ranges from 250 F at full compression to −100 F after a test run. Bed of alumina balls stabilizes temperatures in the tanks.

New high-torque low-current DC motor covers extended range of output speeds

The new Cramer Type 800 direct current motor offers an unusually wide range of output speeds, coupled with low current drain, high torque, high efficiency, and excellent speed stability. These features make it the ideal choice for timing devices, remote control equipment, recorders, signalling equipment, communications gear, displays, flashers, chart transports, and many other products.

Type 800 DC motor with standard gear train — shown 50% oversize

Wide Performance Range

Depending on requirements of speed, torque, and voltage, the rotor is wound to produce a basic motor speed of 960 to 3000 rpm. A gear train then reduces this to the speed required at the output shaft. Low rotor speeds result in lower current drain at all speed-torque combinations, but limit the torque available at the higher output speeds. Higher rotor speeds require a somewhat higher input current, but greatly increase the torque available at the higher output speeds.

The Table at lower right illustrates this flexibility of design, with a few examples from the virtually unlimited range of performance characteristics which it provides. Where very low input current is required, and the supply voltage does not exceed 12 volts, the use of the low-speed rotor will provide 30 oz. in. at speeds below 3 rpm and 0.5 oz. in. at 200 rpm. The higher speed rotors meet the requirements of higher input voltages, and provide greatly increased torque at the higher output speeds with only a moderate increase in current drain. The high-torque motor has the additional advantage of speed stability within 10% from no-load to full-load, at speeds below 5 rpm.

The examples given in the Table are for illustration only. By correct choice of rotor winding and gear ratio, an unlimited number of operating specifications can be established throughout the entire range shown. The motor is also available without gear train, for output torques of 0.1 to 0.6 oz. in. at speeds up to 3000 rpm.

OUTPUT SPEEDS WITH GEAR TRAINS	960 RPM ROTOR LOW INPUT CURRENT (3 to 12 volts DC)		3000 RPM ROTOR HIGH OUTPUT TORQUE (3 to 30 volts DC)	
	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.	INPUT VOLT-AMPERES	OUTPUT TORQUE OZ. IN.
2 rpd	.16	30	.....	.....
1/6 rpm	.16	30	.56	30
3 rpm	.35	24	.64	30
10 rpm	.35	8.5	1.04	30
30 rpm	.35	3.0	1.72	21
60 rpm	.35	1.5	1.72	12
80 rpm	.35	1.1	1.72	8.5
200 rpm	.35	.5	1.72	3.5
900 rpm	.....	.....	1.90	.8

Typical Performance of Type 800 DC Motors for Minimum Input Current or Maximum Output Torque

Specifications

SPEEDS — 2 rpd to 900 rpm with gear train, 960 rpm to 3000 rpm without gear train.

TORQUE — 0.1 to 0.6 oz. in. without gear train, and to 30 oz. in. with gear train.

CURRENT DRAIN — as low as 30 milliamperes, depending on voltage, load and speed.

VOLTAGES — from 3 to 30 volts DC.

REVERSING OPERATION — with negligible speed difference, because of special motor design.

GEARS — precision-hobbed throughout, totally enclosed and with sealed-in lubricant.

For your free copy of informative Bulletin PB-800, write:

CRAMER CONTROLS
CORPORATION

Box 6, Centerbrook, Connecticut

Circle 414 on Page 19

Use of expendable graphite molds and skull casting techniques now permit casting of small titanium parts in vacuum furnaces on a commercial basis. The growing scale of these operations mark . . .

Fig. 1—Aircraft part made by casting titanium in an expendable graphite mold

Progress in TITANIUM CASTING

TITANIUM CASTING on a commercial scale is now considered practical for many applications in which corrosion resistance, rather than strength, is a primary requirement. For other applications, in which the additional requirements of strength and uniformity are imposed, preliminary results are promising. But more work must be done before large and complex castings can be produced commercially.

Especially in the aircraft industry, castings must be uniform and nonporous. A number have been made to date, using expendable mold material. Typical is the part, produced at National Research Corp., shown in Fig. 1. A radiograph of the same casting is shown in Fig. 2. The casting was poured in the furnace shown in Fig. 3. For larger castings, scaled-up versions, like that in Fig. 4, are on the market today. The two shown are made by NRC Equipment Corp.

The development of titanium casting was pioneered, to a considerable extent, by the U. S. Bureau of Mines. Subsequent developments by National Research Corp. led to the first radiographically sound, aircraft-quality castings. Most recently, the casting of titanium has been given impetus by a research and development contract from the Air Force, AMC, Mfg. Methods Branch.

Presently, National Research Corp. is continuing both its casting research and furnace development. The Howard Foundry Co., which realized long ago the potential of titanium castings, is prepared to engage in prototype casting work. Other organizations such as Du Pont, Battelle Memorial Institute, and Oregon Metallurgical Corp. are active in titanium casting research. Mold material developed by Du Pont is particularly noteworthy.

The physical characteristics of titanium should make it attractive for many applications. Its greatest single advantage is lightweight, yet this does not come at the price of undesirable characteristics.

Why, then, isn't titanium used more widely? It's not in short supply, and the government is encouraging its development.

Fabrication

The answer lies in its fabrication. Titanium alloys can be forged, machined, and even extruded—but these are difficult and expensive operations. For example, consider the data shown in Table 1, obtained by some investigators working on drawing titanium alloys.

As for milling and rolling, titanium has long shown tendencies to crack both during fabrication and after installation. One aircraft manufacturer has traced this difficulty to hydrogen content, and has established a maximum of 150 parts per million as the hydrogen content quality control limit.

Machining titanium also presents problems. If heavy tool cuts are taken, the low heat conductivity (combined with the tendency of the metal to spark) causes both the cutting tool and the stock to become hot enough to ignite oil-based cutting lubricants. This dictates the use of nonflammable lubricants for heavy machining operations. Even light machining can be troublesome, since the titanium turnings (particularly the fine ones) may ignite if the metal is turned at high speed without adequate cooling. Another problem in machining titanium alloys is toughness. Although pure titanium is fairly soft, the alloys possessing adequate strength are tough and difficult to machine. Minute amounts of gas, such as oxygen, nitrogen, and hydrogen, impart brittleness to titanium alloys, complicating the fabrication further.

Finally, welding titanium requires controlled (argon) atmos-

Fig. 2—Radiograph of casting in Fig. 1 indicates soundness essential in aircraft part.

By John V. E. Hansen and Philip J. Clough

National Research Corp.
Cambridge, Mass.

pheres. At high temperatures titanium reacts with air and precludes routine welding techniques.

It should be stressed that these formidable obstacles to titanium fabrication are not insurmountable. However, they are factors that increase the cost of the fabricated titanium alloys, thus limiting the incentive to use titanium in many installations. Considering this, the casting of titanium and its alloys deserves some attention. Here again, however, nature imposes a strict set of rules.

Casting

In molten form, titanium is an extremely reactive metal. Therefore, any melting of the metal must be done in vacuum or under a controlled inert atmosphere such as argon. Recent evidence indicates that vacuum melting is far more desirable. Fortunately, vacuum melting equipment and techniques have progressed to the point where this does not constitute an obstacle. In fact, the benefits of vacuum melting, such as cleanliness and the absence of gas that will cause embrittlement, would probably dictate its use even if titanium could be melted in air.

The vacuum casting of titanium

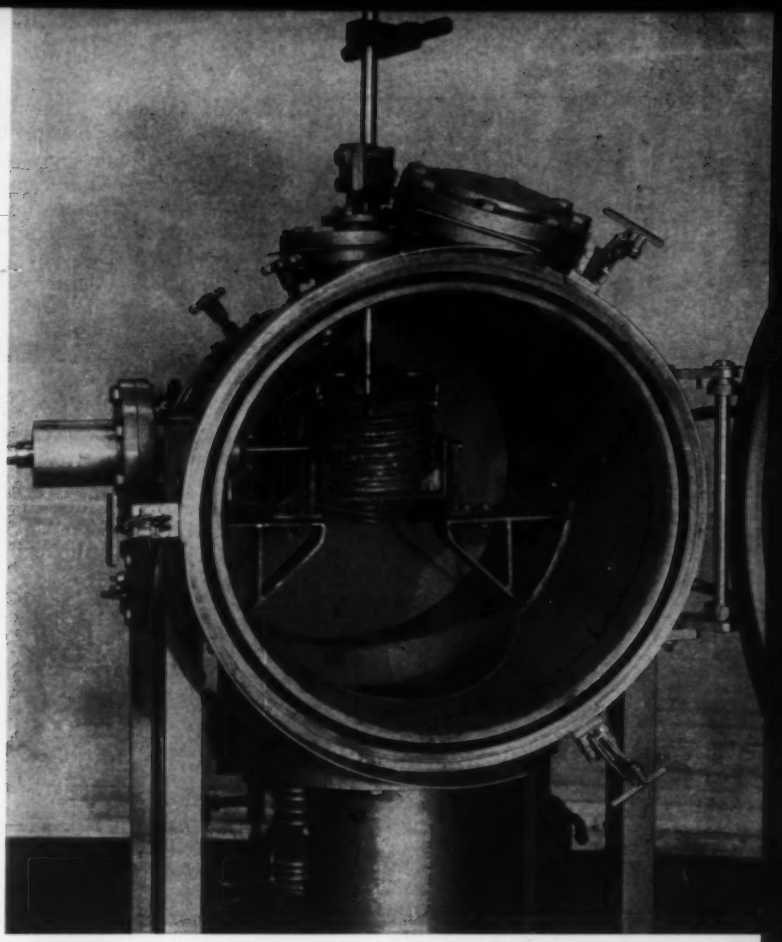


Fig. 3—Furnace in which the part in Fig. 1 was poured. When titanium is the melt, vacuum assures casting purity better than any atmosphere

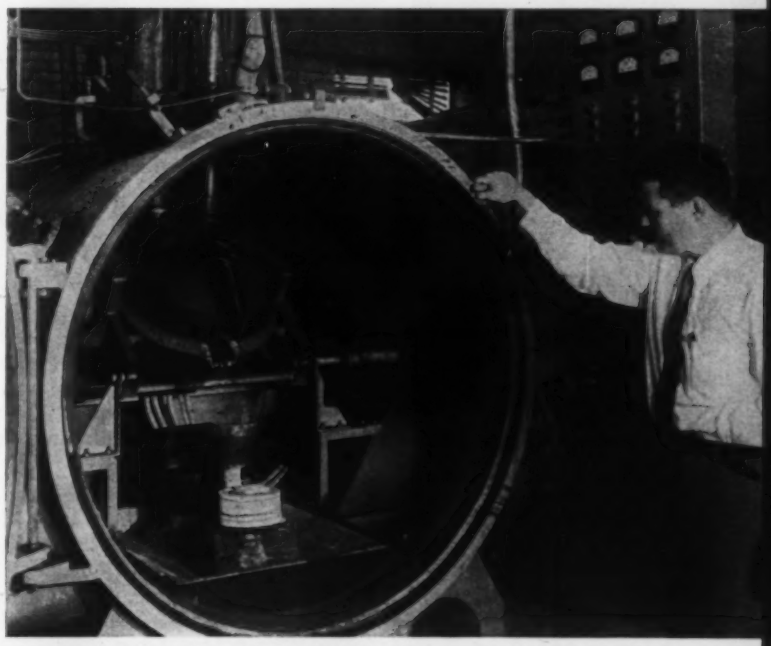


Fig. 4—Larger vacuum furnace for casting titanium employs skull melting principle in which crucible is lined with same metal being melted

Table 1

Material	Drawing Speed
Brass	150 fpm
Aluminum	100 fpm
Steel	55 fpm
Titanium alloy*	6 ipm to 5 fpm

*5% aluminum, 2½% tin, balance titanium

has been the subject of considerable investigation in recent years. The first problem in melting the titanium is to devise a means of keeping it molten (prior to pouring) without having it react or combine with the container or crucible. This can be overcome by a combination of consumable melting (arc-melting a titanium electrode) and skull melting. Skull melting consists of melting metal in a crucible that is equipped with a solid liner of the same material as that to be melted. The temperature gradient across the liner is such that the molten material is not in contact with the crucible. Water-cooled copper crucibles are in wide use today in many skull melting operations.

Once the titanium is molten in vacuum, the next problem is the mold. Here the reactivity of titanium presents a problem. Most known refractories such as silicates, alumina, and stabilized zirconia are useless because they are severely attacked or dissolved upon exposure to the superheated (3500 F) titanium. The approach has therefore been to chill the poured titanium rapidly so that it will freeze before reacting excessively with the mold material.

If the molten titanium causes gas to be released from the mold materials, the castings are bound to exhibit porosity. If the mold material reacts it will produce a very rough surface on the casting. Extensive machining is then required, but this seems to be defeating the purpose. The problem will be compounded if the mold materials create surface contamination on the castings.

Graphite Molds

To date, graphite-based materials have proved to be the most suitable for titanium casting molds. An interesting sidelight is that during an investigation of a wide variety of mold materials (including machined copper), porous castings continued to result. Finally, it was discovered that minute amounts of gases evolved during the casting operation were not originating from the mold materials, but from the titanium itself. Unreacted chlorides introduced in the titanium during the reduction of the metal were responsible. Once this became known, melting techniques were devised to remove the gases.

There are, at present, two proved methods of using graphite to produce titanium castings. One is to literally machine the molds out of solid graphite; the other is to build a mold out of graphite mixture. Although work is fairly recent on both techniques, both methods show acceptable surface quality. Surface finish is relatively smooth, and surface contamination is small. Using expendable graphite material, surface contamination is on the order of 0.005 in. Using machined graphite, surface contamination is shown to be less than 0.030 in. Published radiographs of experimental castings made by the expendable (molded graphite) mold technique at National Research Corp. show completely sound, nonporous castings. Although no radiographs of completely sound castings produced in machined graphite molds have been published to date, it seems reasonable to expect that such castings can be produced.

If sound castings can be made from both types of molds, the choice is then largely governed by economics. Machined graphite molds can be re-used several times, and some investigators report having re-used molds as many as 30 times. The re-usability of graphite molds would be a function of the sharpness of the corners in the mold pattern and the extent to which these and other critical sections are damaged by successive pourings. In addition, of course, the normal wear from repeated exposure to the molten titanium would limit the life of such molds.

Machined graphite molds have a disadvantage in that their cost is a function of the complexity of the final casting. Relatively simple machined graphite molds have been estimated to cost about $50. Complex machined graphite molds, particularly those in which dimensional tolerances are critical, would cost considerably more. Paradoxically, the more complex and expensive the mold, the greater the likelihood of shorter life. This is true particularly where the final castings contain sharp corners or intricate configuration.

By comparison, expendable graphite molds offer distinct promise for large-scale production of titanium castings. Their cost is largely a function of the amount of material required—relatively independent of the complexity of casting. Preliminary cost estimates (which, as a rule, can be trimmed by improving techniques and expanding to production quantity operations) of small expendable molds are on the order of $2 per mold. One factor that may reduce this is the possibility of re-using (by regrinding and remolding) the mold material. Again, it must be emphasized that this figure is largely independent of the complexity of the casting once the pattern has been made. Increasing the mold size would be primarily a function of the mold material required, which costs approximately $0.14 per pound.

Regardless of the type of graphite molds used, improved mold design unquestionably will have an effect on the cost of castings. Since titanium freezes very rapidly, the mold must be provided with sufficient gates and risers to insure adequate fill in the mold. In titanium casting today, gates and risers may account for 50 per cent or more of the metal poured. Recovery of this material is being attempted in two ways: Improved mold design to eliminate the amount of waste material poured, and re-use of the waste titanium by reintroducing it to the melting cycle. The latter technique is particularly promising and is in use today in several organizations.

In the future, it appears that work remaining in the casting process is the scaling-up of present techniques to produce large and complex shapes. Beyond that, the problem is largely one of putting titanium castings to use in industry. As with any new item, once the castings have gained acceptance in the field, it would be logical to expect a number of new applications to develop.

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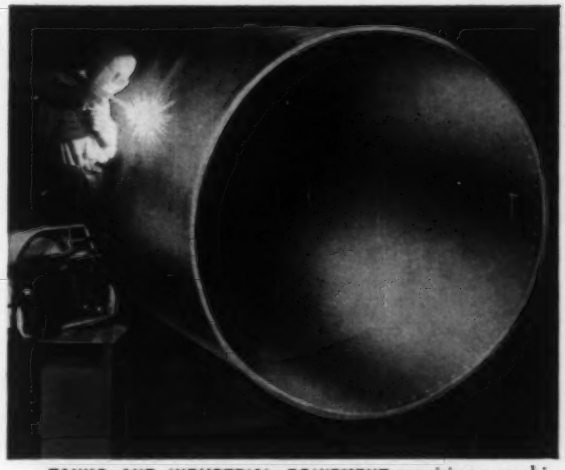

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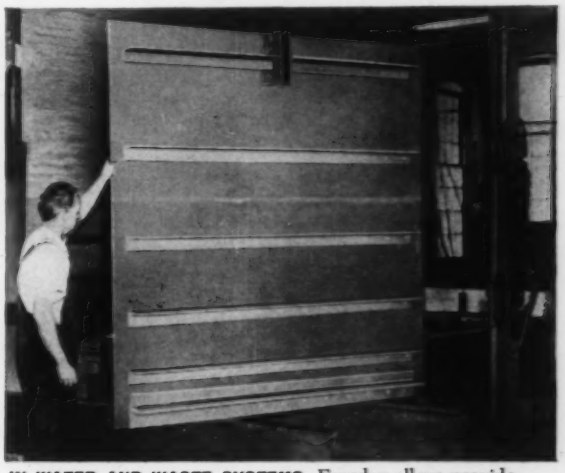

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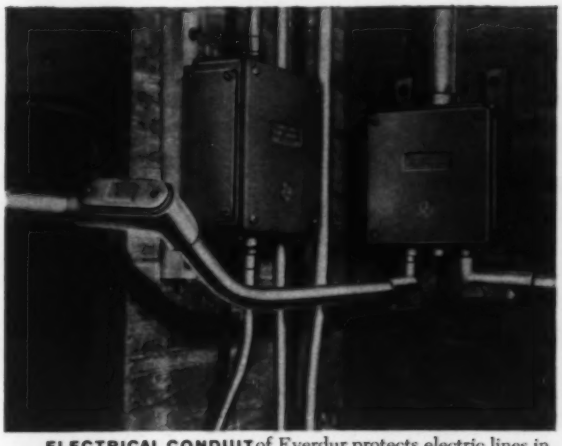

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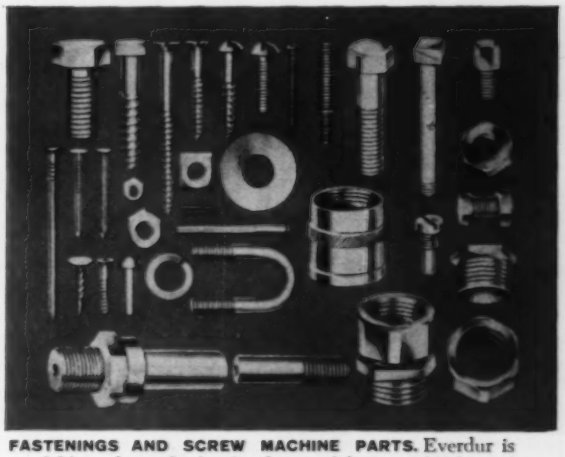

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ALL BUT AXIOMATIC is the principle that engineers need good working conditions and equipment to do good work. With these, the engineer can concentrate more fully on his work. He can enjoy enhanced prestige, improved motivation, and greater productivity—and the company benefits directly.

According to the survey, *Engineering Manpower: How to Improve Its Productivity,** on which this series of articles is based, rearranging a work area in one company resulted in an estimated 25 per cent increase in engineering productivity. Such estimates of savings are at the most, however, only rough indications. It is difficult to calculate savings as a result of improved working conditions because savings in time are only indirectly translatable into dollars and cents.

This difficulty in measuring engineering performance appears to be one reason why some managements pass lightly over improvements in engineers' working conditions. As disclosed by the survey, most companies do recognize the importance of good working conditions, but do

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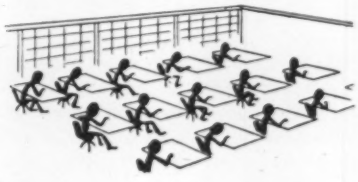
Checkpoints for Engineering Management

- ☑ **1. Are high noise levels in engineering areas seriously detracting from productivity?**
- ☑ **2. Does your firm have a high turnover rate, traceable to less-than-average working conditions?**
- ☑ **3. What practical changes in your facilities would significantly improve morale and utilization of engineers?**
- ☑ **4. Can you profit by using conference rooms, computers, or library facilities to a greater extent?**
- ☑ **5. Do good economics in fact preclude any further improvements in engineers' working conditions?**

Conditions and Equipment

too little to correct even clearly inadequate conditions. In scanning engineers' working conditions, the survey emphasized several considerations: 1. Types of work areas. 2. Engineering facilities. 3. Definitions of good working conditions.



Work areas are important

Large work areas are often used by companies in the electronics, aircraft, and guided missile industries, employing from 100 to 5000 engineers at one location. The survey found offices in which anywhere from 100 to 1000 engineers were located in one large loft or high-ceilinged room. Sometimes the areas were especially designed for engineers. Other times, the sudden and tremendous growth of the engineering force had outstripped existing facilities, and lack of time or funds made mass quarters absolutely necessary.

Noise level was invariably high. Conversation at normal voice level was found to be difficult and at times, impossible. Some engineering offices were located next to shop areas, shipping rooms, or production lines. Clerical facilities, sometimes intermingled with engineering desks and tables, added the ringing of telephones and clatter of typewriters to the background noise.

The survey found that engineers housed under such arrangements were for the most part dissatisfied. They complained most often about the lack of quiet or privacy that detracted from their ability to concentrate. Numerous replies to the survey were summed up by the comment of one aircraft engineer:

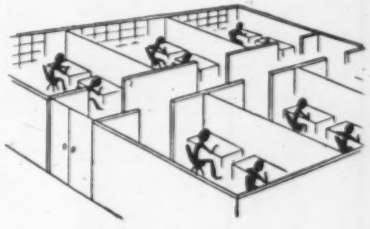
> • The hardest part about working in such large rooms with so many people is the constant incessant noise of conversation, gongs, and walking around. There is always some group meeting somewhere—in the next aisle or several desks down. All in all it makes it hard for me to keep my mind on my work. Others feel the same way.

In large offices, supervisors are very often assigned desks in small rooms or cubicles off the main work area. But even they usually report it is difficult or impossible to concentrate in such rooms because of the high noise level. One highly placed engineer in an East Coast company reported, "My hour of productivity begins after working time when everyone around has left."

Explaining why such large areas are used, several executives reported that the inadequacy of such conditions is obvious and clearly recognized. Yet, they maintained, the company could not afford the large fixed expense of constructing and maintaining improved quarters for engineers because government cancellation of a contract could eliminate the need for such large numbers of engineers in a short time.

The company, the executives said, would then have to maintain unused work space. They pointed out further that construction of such facilities was not reimbursable under government contracts. While such conditions do impair engineering productivity, they said, the company compensated by employing more engineers which, under government contracts, was a reimbursable expense.

Subdivided working areas for engineers, according to survey findings, are characteristic of most American companies. They are used by companies employing large numbers of engineers as well as by medium-sized and small firms. In general, companies with this type of work-



area arrangement appear to be older, more mature companies in which the number of engineers employed has risen less rapidly than companies making use of the large work areas.

Many companies quarter their engineers or engineering working groups in individual rooms. Size of the work group varies according to the nature of the work. The most frequent number found by the survey was three or four persons. Other

Recommendations for Management

1. Ask the engineers.

Probably the best way to find out what engineers' working conditions are like is to ask them. Management must then decide which complaints can be corrected with a reasonable outlay of funds and which must be left uncorrected.

2. Don't go overboard.

Don't coddle engineers. They need marble palaces, private offices, and banks of expensive equipment far less than the opportunity to work without interruption, to have access to other sources of information, and to carry on discussions and conferences with colleagues in private.

3. Screen engineers' complaints.

This is especially important for companies where working conditions are already adequate. Here, investment in improved facilities will probably result only in marginal improvements in engineering productivity. Where working conditions are substandard, however, management is strongly advised to make some immediate investment in improvements. Failure to do so will impair engineering productivity and ultimately affect the company's competitive standing.

4. Expect engineers' complaints.

The engineer can be expected to be dissatisfied when the noise level or commotion in his work area is excessive. Similarly if the temperature, humidity, lighting, power sources, or communication facilities are inadequate, he cannot be expected to achieve even reasonable efficiency. These considerations are obvious, but it is surprising how frequently engineers complain of these same conditions. Often, installing relatively inexpensive soundproof tile alone will result in substantial improvement.

5. Justify the investment.

Management must weigh the merits of providing equipment and other facilities for engineers before making investments. Just as management must inform itself about what type of facilities engineers feel they need, the investment must be justifiable on the grounds that efficient use will be made by all or a large number of the engineers. Libraries, conference rooms, computers, and other aids will all be money down the drain unless the engineers know how and want to use them.

times, however, as many as ten or twelve engineers worked together in such rooms or cubicles.

Where laboratory or experimental areas are necessary, they are usually centralized in a nearby location, where they may be used by engineers from any one of a number of offices. A characteristic of this type of arrangement is that clerical personnel usually work in the same rooms with the engineers. Distractions are not erased. They still result from conversations and the noise of telephones and typewriters. Despite these, engineers generally seem satisfied with the subdivided work-area arrangement.

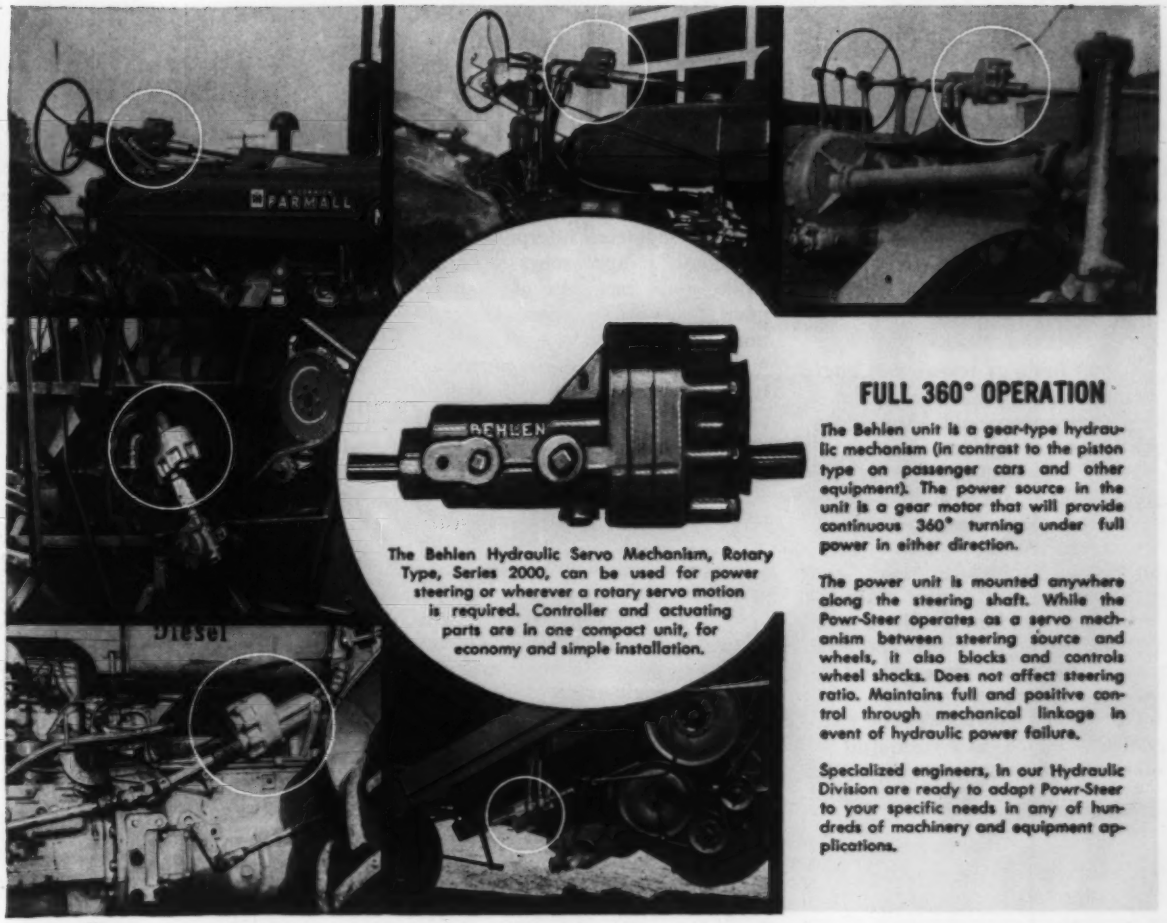
Although executives cannot agree on the number of engineers that work most efficiently together, companies recognize that privacy bears greatly on engineering productivity. A number of companies have installed partitions or constructed cubicles to allow their engineers greater privacy.

Under such arrangements, each engineer usually has his own desk, bookcase, and other equipment for personal use, rather than sharing bookcases and similar items. Several companies have estimated the investment required for desk, bookcase, and partition at $550 per engineer. Amortized over a 5-year period, including maintenance, this amounts to a cost of $7.50 per engineer per month.

Combined office-work areas find favor with some companies. Many arrange for engineers or small engineering groups to have their own combined office-work space (laboratory or experimental area). Sometimes the work space and the office are located in adjoining rooms; sometimes one room serves both purposes.

Clerical facilities, separate from the engineers' quarters, are usually located nearby. The number of people assigned to such quarters is generally small. One to three engineers were most commonly assigned to such a room.

This arrangement is used most often where research or experimental work is conducted. It is costly and may result in idle equipment unless a considerable amount of research or experimentation work is being carried out all of the time. The engineers involved are usually



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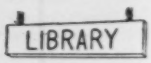
capable of working without close supervision.

There are almost no distractions, privacy is maintained, and engineers are almost always satisfied with the work situation. Some of the electronics companies in particular are beginning to make increased use of this type of arrangement.

Engineering facilities

Survey findings reveal that engineering facilities and equipment in most companies could be considerably improved without passing the point of diminishing returns. Diverse facilities are available among the various companies contacted. Included are test areas, model shops, darkrooms, conference rooms, and such services as a central blueprint department, drafting facilities, specification writing, instruction-book writing, messenger systems, and legal advice on patent matters.

Only about one-half of the companies surveyed have technical libraries in their plants. These are



important both as a source of specific information and as a means of motivating engineers to keep up with progress in the field. In many large companies, a library staff helps engineers research past reports and literature. But a number of the engineering supervisors contacted felt that the library-staff concept could be easily overdone. They contended that a good engineer may profit more by conducting his own library research. He may run across challenging information, which he otherwise would not have seen.

Libraries and model shops, although expensive to maintain, are not found only in the larger companies. For example, one excellent company library noted in the survey is provided by an electronics company which employs less than 50 engineers. It is partitioned off from the rest of the engineering work area; it is comfortable and quiet. Manufacturing journals, technical books and magazines, as well as unclassified articles, and more than 500 reports prepared by the company's own engineers are available for study.

Definitions of good working conditions

Executives and engineers disagree about what constitutes good working conditions. Survey replies show that the engineers' interpretation of "adequate" approaches "ideal," while some members of management believe that adequate conditions are in fact "ideal."

Some executives and management representatives said they were completely unaware that their engineers were bothered by high noise levels and nearby activities. A few executives even confided with pride, "We have trained our engineers to work under distracting conditions," but left unexplained how they had contrived this deft manipulation.

Where working arrangements were clearly too crowded, distracting, and generally not conducive to high engineering productivity, morale of the engineers was low. High turnover rates and absenteeism resulted.

In those companies where working conditions with respect to work space and noise level left much to be desired, but management was actively trying to improve working conditions, engineer morale was con-

siderably higher and turnover and absenteeism were lower. This evidence suggests that there is a certain minimum level in working conditions. When conditions slip below that level, productivity is markedly impaired.

One of the facilities found most often lacking was confefence space. Usually the space simply was not available for conference rooms. But the survey noted several times that space could easily have been provided if management had wished to fulfill repeated requests of engineers.

Next article in this series will appear in the May 1 issue. It will deal with supporting personnel for the engineering department, including highly trained specialists, technicians, and nontechnical assistants.

TRANSISTORS UNDER GLASS, instead of metal, may be commercially available later this year. According to General Electric, the glass package is cheaper than metal and glass also is more easily adapted to inexpensive, volume production

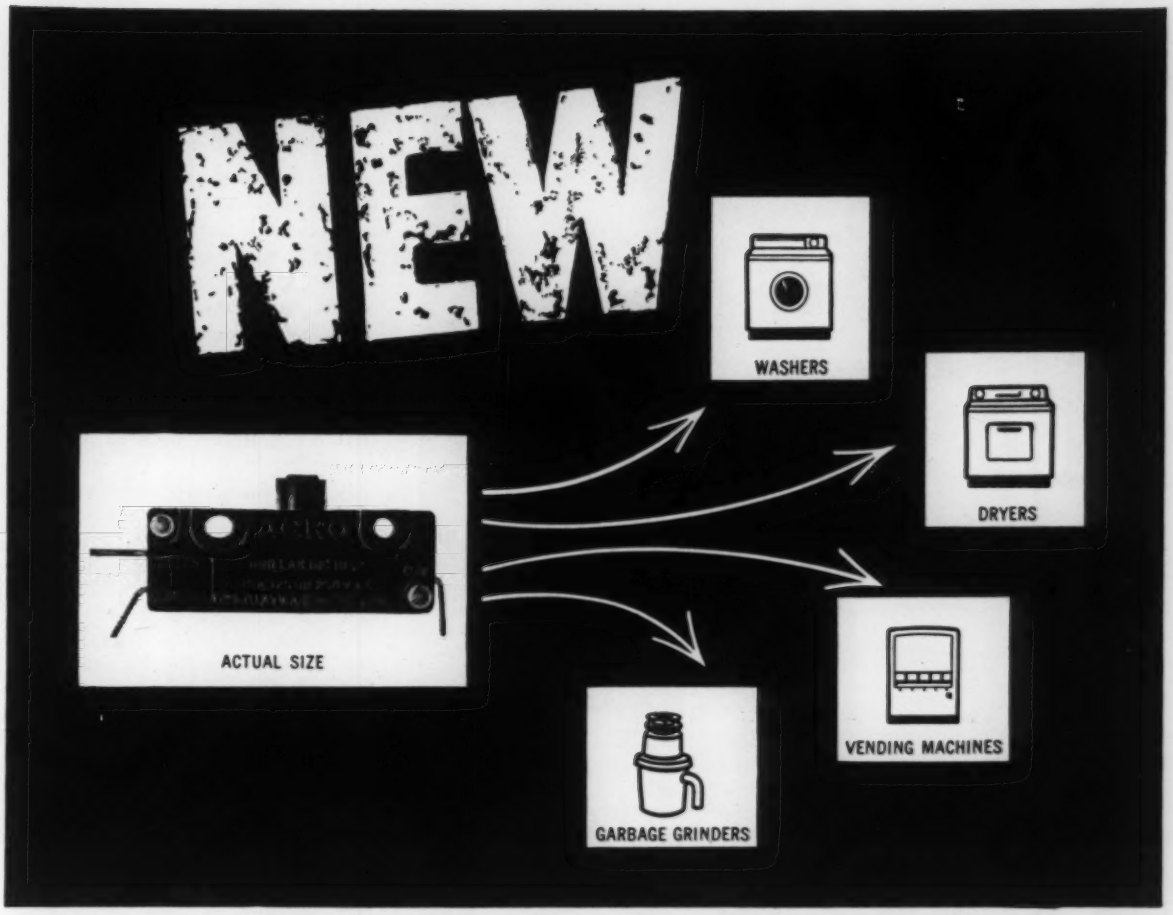
Russian Scientist Describes Thermonuclear Techniques

Tells of Soviet Advances In Achieving Fusion Power

Moscow—Agreeing that physicists and engineers throughout the world still have a great deal to do before the way to industrial use of thermonuclear power becomes perfectly clear, Russian scientist Igor Kurchatov, in a recent article in *Pravda*, outlined Soviet progress in achieving controlled thermonuclear reactions.

He described research in 1956 in which rarefied deuterium was heated to a temperature of more than 1 million C by an electric current of up to 2 million amp, and the emission of neutrons was observed. Current Soviet investigation, he said, is concerned with discharges in doughnut-shaped chambers, but the types used are somewhat different from the British. "We intend to report about this work at the Second International Conference for the Peaceful Uses of Atomic Energy in Geneva this year," he said.

He commented that with the development of thermonuclear reactors, the problem of dwindling fuel supplies will disappear practically forever, and suggested that in the future, principal thermonuclear reactors will use pure deuterium. A "deep-freeze" method, he said, has been developed by the USSR Academy of Sciences, where-



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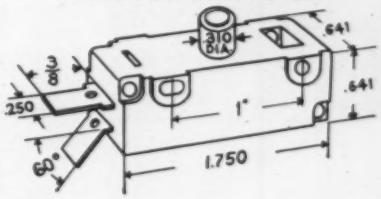

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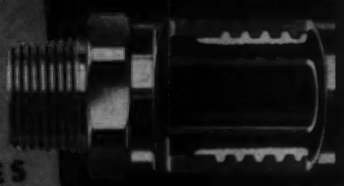
Circle 417 on Page 19

This Inside Story tells you why ANCHOR® HOSE ASSEMBLIES Meet Your Most Rigid Requirements



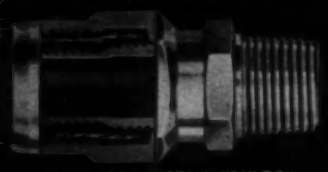
ANCHOR HIGH PRESSURE DUCTILE SLEEVE COUPLING TWO WIRE BRAID HOSE ASSEMBLY

When we speak of "inside story" in this case, we primarily refer to the cross-sectional views shown which obviously confirm both design and construction advantages built into all Anchor Hose Assemblies.

But, further and beyond these obvious benefits, we also refer to the intangible advantages evolving from years of experience in the designing and manufacturing of Hydraulic Hose Assemblies—advantages that can only be verified by actual usage—advantages that do not show up until you reach those bonus months of dependable service, which all users of Anchor Assemblies KNOW about and keep coming back for, order-after-order.

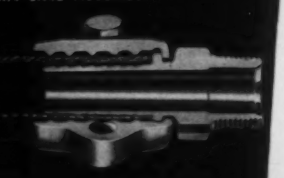
Anchor Hydraulic Hose Assemblies are made in many styles for high, medium and low pressure service, for use on virtually any type of equipment employing a hydraulic system. Maximum working pressures range from 100 PSI in the 2" I.D. spiral wire assemblies to 7,000 PSI in ¼" I.D. 3-wire braid assemblies. A wide variety of coupling styles are available to suit the requirements of your specific installation.

ANCHOR FLANCO BENT STEM 22½° HIGH PRESSURE TWO WIRE BRAID HOSE ASSEMBLY (30°, 45°, 60°, 67½° and 90° also available)



ANCHOR COMMERCIAL "DULOC" REUSABLE COUPLING ON STYLE QW HOSE

MAX-FLO SUCTION HYDRAULIC RETURN LINE ASSEMBLY

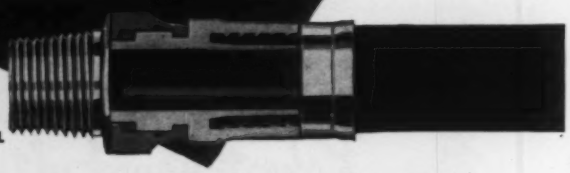


ANCHOR CLAMP TYPE REUSABLE COUPLING USED ON TWO WIRE BRAID HIGH PRESSURE HOSE

Andy Anchor Says:

Take the first important step to acquaint yourself with Anchor Hose Assembly quality, if you are not already using them—write for Catalog No. 57S giving detailed specifications on high, medium and low pressure hydraulic assemblies. Request Catalog No. 57S—NOW!

MAX-FLO ONE WIRE BRAID MEDIUM AND LOW PRESSURE HOSE ASSEMBLY WITH SWIVEL MALE COUPLING



ANCHOR COUPLING CO. INC.

330 North Fourth Street, Libertyville, Illinois

Branch Offices: Dallas, Tex., Plymouth, Mich.

Circle 418 on Page 19

by deuterium is produced on an industrial scale at a temperature of − 250 C.

He discussed containment of plasma inside reactors with the magnetic field keeping it away from the walls, and then spoke of another method of achieving heat insulation by the use of thick chamber walls:

"When a strong electric current is passed through the plasma, the magnetic field can be used for heat insulation. . . . the walls of the chamber must be made of a thick conducting material. The magnetic field will completely surround the plasma through which the current passes. If the current is excited by an impulse, its magnetic field cannot penetrate into the metal quickly, and will therefore keep the plasma away from the walls." Citing the use of copper walls, he said, "In this case the heated plasma would press on the walls, not through the impact of the molecules, as in cold gas, but through the magnetic field of the current through the plasma."

He discussed the possibility of producing electric power directly from thermonuclear reactors, without the conventional, energy-dissipating cycle through steam turbines and generators. "This possibility is based on the fact that in the deuterium plasma more than two-thirds of all the power is emitted as the kinetic energy of charged particles. The charged particles are held by the magnetic field, and . . . the kinetic energy of particles can be directly converted into electric energy.

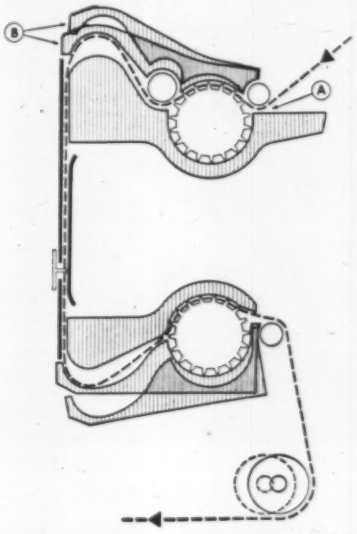
"A pulsating electric current can be obtained, for example, in the following manner: Let us assume that the plasma is held by the outer magnetic field created by the current in the winding of the thermonuclear generator. If we increase this field a little, the plasma will be compressed further and its temperature and density will increase. This will speed up the thermonuclear reaction and will heat up the plasma still more. The plasma will begin to expand, cooling and expelling the magnetic field from the volume of the reactor. Magnetic lines of force will cross the winding, inducing an electric current in it. At a certain stage the power of

this current will be greater than the energy expended on compressing the plasma."

Self-Threading Projector Aids Home-Movie Fan

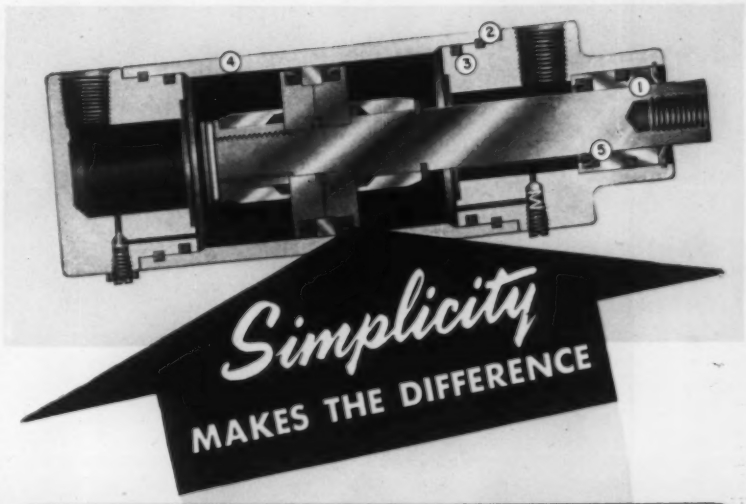
CHICAGO—The first 8-mm projector to thread itself is aimed at simplifying the home-movie fan's task. Bell & Howell's latest contribution to "pushbutton" photo equipment is its Auto-Load projector, claimed to whisk the film through the threading path in less than 3 sec.

Design of the self-threading mechanism is based on surfaces that



guide the film according to its own compliance. The movie maker about to show his latest production inserts the film in the threading channel *A* of the new projector. The automatic threading mechanism engages the sprocket teeth, forms the film loops, and directs the film through the channel between aperture and pressure plates, all the while handling the film gently by its edges. Film threading follows the dashed line in the diagram.

One feature of this device is its ability to restore a lost film loop without stopping the projector. When the loop is lost, because of torn perforations or warped film, the operator momentarily presses down the loop former *B* to restore the loop and give a steady picture.



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CHECK THESE DESIGNERS' FEATURES:

1. **Full 1 to 1 Meehanite Cartridge rod bearing for easy replacement.**
2. **Key type stainless steel locking ring; Strength plus 360° orientation of pipe ports.**
3. **Leakproof service.**
4. **Precision honed heavy wall tubing—6 to 1 safety factor.**
5. **Self adjusting packing; Low friction breakout!**

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The Carter line is engineered to give you the best cylinder! Strong, modern construction! No tie rods or bolts—a strong, simple key lock between head and wall lets you orient pipe ports a full 360°. Compact size gives you more space and flexibility in design.

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Complete designers' file gives specifications and details on all models. Send today!
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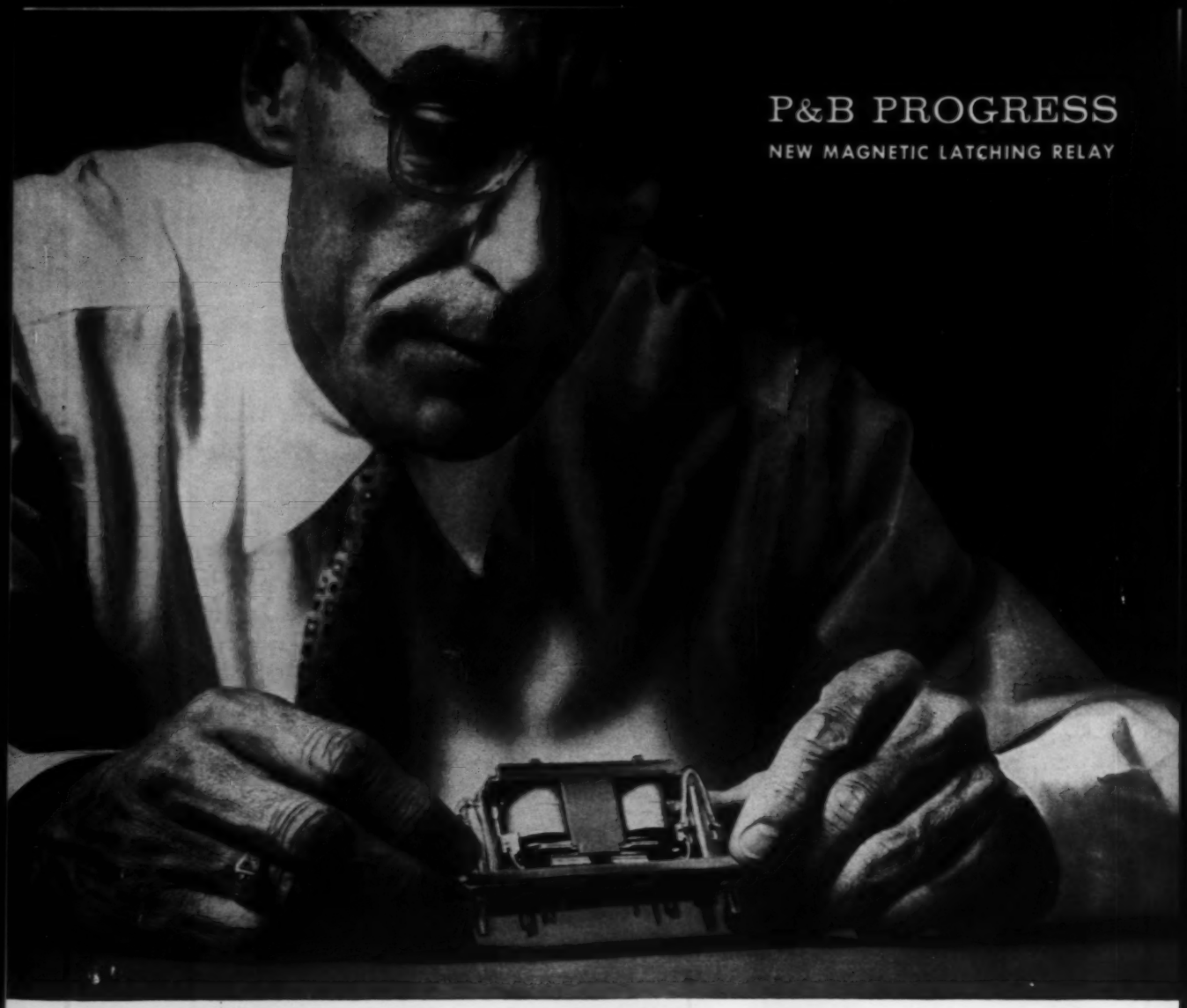
ROTARY ACTUATORS • SPECIAL CONTROLS

Circle 419 on Page 19



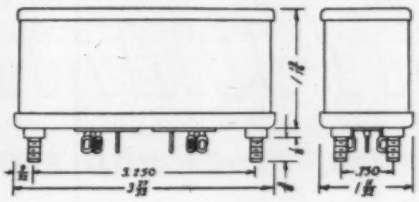
NEW RELAY SWITCHES 30 AMPS

Withstands 100g Shock* and 30g Vibration, 55 to 2000 cps.

KG11DG is an extra heavy duty DPDT *magnetic latching* relay. Its silver cadmium oxide contacts will carry 30 amperes, and the whole structure will withstand 100g shock*. Vibration resistance is 30g, 55 to 2000 cps. A permanent magnet is employed to (1) lock the armature into position, (2) accelerate armature transfer, and (3) greatly increase shock and vibration resistance. • KG23D is a 6PDT version of this relay with the contacts rated at 3 and 5 amperes. It has the same shock and vibration resistance and operates with exceptional reliability over a range of contact loads from dry circuits to 5 amperes, 28 volts AC, resistive.

**Contact openings of less than 80 microseconds.*

POTTER & BRUMFIELD, INC., PRINCETON, INDIANA/SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



KG11DG RELAY		KG23D RELAY
30 AMPS	**GENERAL**	**3 & 5 AMPS**
Teflon, Glass & Ceramic.	—Insulation—	Teflon, Glass & Ceramic.
1000 megohms min.	—Insulation Resistance—	1000 megohms min.
1000 volts rms.	—Breakdown Voltage—	1000 volts rms.
100g with less than 80 micro-seconds opening.	—Shock—	100g with less than 80 micro-seconds opening.
30g from 55 to 2000 cps; .195" max. excursion from 10 to 55 cps.	—Vibration—	30g from 55 to 2000 cps; .195" max. excursion from 10 to 55 cps.
—65°C. to +125°C.	—Ambient Temperature—	—65°C. to +125°C.
13 ozs.	—Weight—	13 ozs.
12 ms. with 225 ohm coil @24V DC.	—Pull-in-Speed—	12 ms. with 225 ohm coil @24V DC.
Two 5-pin multiple solder headers. Contacts: Heavy-duty pierced solder terminals. Coils: Hook end for 3 #20 AWG wires.	—Terminals—	Two multiple solder headers with hook ends for 3 #20 AWG wires.
Hermetically sealed only.	—Enclosures—	Hermetically sealed only.
	CONTACTS	
2 Form Z. (DPDT Double make—double break)	—Arrangements—	2, 4, and 6 Form C.
30 amps @28V DC resistive.	—Load—	Dry circuits. 5 amps @28V DC resistive. 3 amps @115V AC resistive.
Silver cadmium oxide.	—Material—	Palladium (Gold-flashed for dry circuits).
	COIL	
2.6 watts approx. at nominal voltage. Either coil may be left energized without damage.	—Power— —Duty—	2.6 watts approx. at nominal voltage. Either coil may be left energized without damage.
Teflon tape and Ceramic.	—Insulation—	Teflon tape and Ceramic.
Four 3/8 inch #8-32 studs on 3¼ x ¾ inch centers.	—Mounting—	Four 3/8 inch #8-32 studs on 3¼ x ¾ inch centers.

Voltage:	6VDC	12VDC	24VDC	48VDC	110VDC
Resistance:	14 ohms	55 ohms	225 ohms	835 ohms	5500 ohms

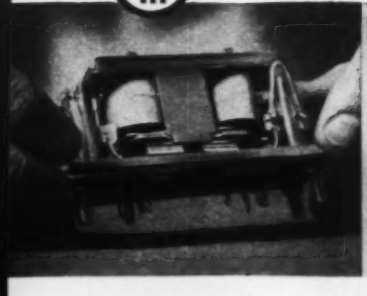
P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

Potter & Brumfield, inc.

PRINCETON, INDIANA

SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

Manufacturing Divisions also in Franklin, Ky. and Laconia, N.H.



Potter & Brumfield, Inc., Princeton, Indiana
Attn: T. B. White, Brig. Gen. USMC (Ret.)
Special Projects Engineer

Please send me complete data on the new KG Series relays, plus the new compact catalog of P&B standard relays.

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Company_____ Dept. No._____

Address_____

City_____ Zone_____ State_____

See our catalog in Sweet's Product Design File

Tool Gives Aircraft Rivets Smooth and Flush Flat Pates

SEATTLE—Close, smooth shaves are given rivet heads by a novel tool devised at Boeing Airplane Co.

Specifications require that head protrusion beyond the skin of high-speed aircraft be held less than 0.002 in. Shaving to this limit is no trick if rivets are aluminum or magnesium, but quite another mat-

ter if stainless steel or titanium. The Boeing tool does the latter job well.

A standard 1-in. arbor-type, tungsten-carbide, rotary file is mounted in a ¼-in., portable, air drill in such a way that the cutter rotates on two axes. An adjustable, threaded housing controls the depth of cut. The file is driven at 4180 rpm. Its dual rotation gives high finish to the rivet heads. More than 1000 titanium fasteners are shaved before the file needs resharpening.

Says Report Index Would Reduce Waste

Cites Technical Communication As Major Problem Area

DALLAS—A central index for technical literature would reduce the waste of time, efforts, and money on projects that unnecessarily duplicate work done elsewhere, said a high ranking Naval officer recently in a talk before the American Rocket Society. "The Dept. of Commerce or the National Science Foundation might well serve as the repository of information from the

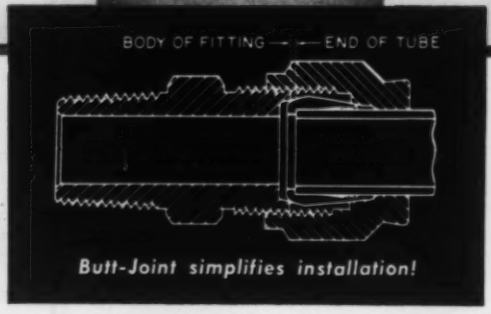
IMPERIAL HI-SEAL BUTT-JOINT FITTINGS

now available in brass, steel and stainless steel

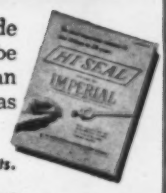
- No flaring or threading
- Withstands higher pressures
- No need to spring tubing
- Permits closer tube bends
- Fast, foolproof assembly
- Meets J.I.C. and A.S.M.E. standards . . . Listed by UL

Tremendous popularity of steel and stainless steel Hi-Seal fittings has led many users to request Hi-Seal fittings in brass. You wanted them—Imperial made them — new brass Hi-Seal fittings . . . plus steel and stainless steel fittings so you can profit from famous Hi-Seal advantages . . . like butt-joint, close bends, quick assembly in the metal best suited to each application.

Tube doesn't enter the body of the fitting. It bottoms on shoulder of the sleeve. Camming action of the nut causes sleeve to form a collet-type triple-seal grip on the tubing.



Final circumferential seal is made by tapered edge of sleeve. No tube torqueing when making a joint. Can be disconnected and reconnected as often as desired.



Write for Bulletin 3061 and complete facts.

See Your Imperial Distributor

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IMPERIAL—offers industry's most complete line of fittings and tools for steel, stainless steel, copper, aluminum and plastic tubing.

FLARELESS TYPE FITTINGS

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HI-DUTY
Brass
Aluminum

FLEX
Brass

POLY-FLO
Brass

NYLO-SEAL
Nylon

ERMETO
Steel

COMPRESSION
Brass

FLARED TYPE FITTINGS

37° FLARE
Brass
Steel
Stainless Steel

45° HEAVY DUTY FLARE
Brass

45° FLARE AND INVERTED FLARE
Brass

BRASS PIPE FITTINGS

PRESSURE HOSE AND REUSABLE COUPLINGS

Rubber Covered, Rayon Braid Hose — for low pressures.

Cotton Covered, Single Wire Braid Hose — for medium pressures.

Non-Skive Rubber Covered, Single Wire Braid Hose — for medium pressures.

Rubber Covered, Single Wire Braid Hose — for medium pressures.

Rubber Covered, Double Wire Braid Hose — for high pressures.

FLUID CONTROL AND SHUT-OFF VALVES

Needle Type
Toggle Type
Diaphragm Type
Plug Type
2, 3 and 4-way styles

TUBE WORKING TOOLS

CUTTERS
Tube Cutters
Sawing Vises

FLARING TOOLS
45° Flares
37° Flares
Double Flares

TUBE BENDERS
Lever Type
Gear Type
Spring Type

Reamers
Swaging Tools
Test Plugs and Caps
Refacing Tools

Emblem of Quality

Circle 421 on Page 19

various departments and agencies of government and members of industry to be used in the preparation of such a listing," said Rear Admiral Rawson Bennett, Chief of Naval Research.

"This matter of communication is one of the major problems which confront us in science and engineering today. The task of informing engineers on past work that has been accomplished in basic research is one of enormous dimensions."

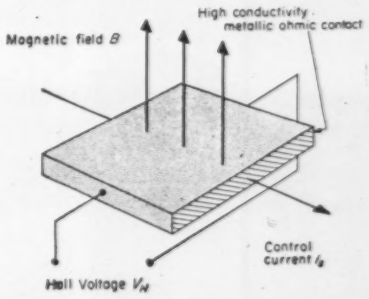
There are many people in government and industry who have been working on the problem, he explained, but there is no established system for coding, cataloging, or abstracting which meets the requirements of disseminating the ideas on a nation-wide scale.

Admiral Bennett suggested the writing of the classical abstract of a report might be made optional with the author. He urged each author, however, to note on the front of each report the most important single result achieved by the work described. Such a system, he contended, might permit better indexing and thus improve our utilization of work already done.

New Computer Element Uses Long-Known Principle

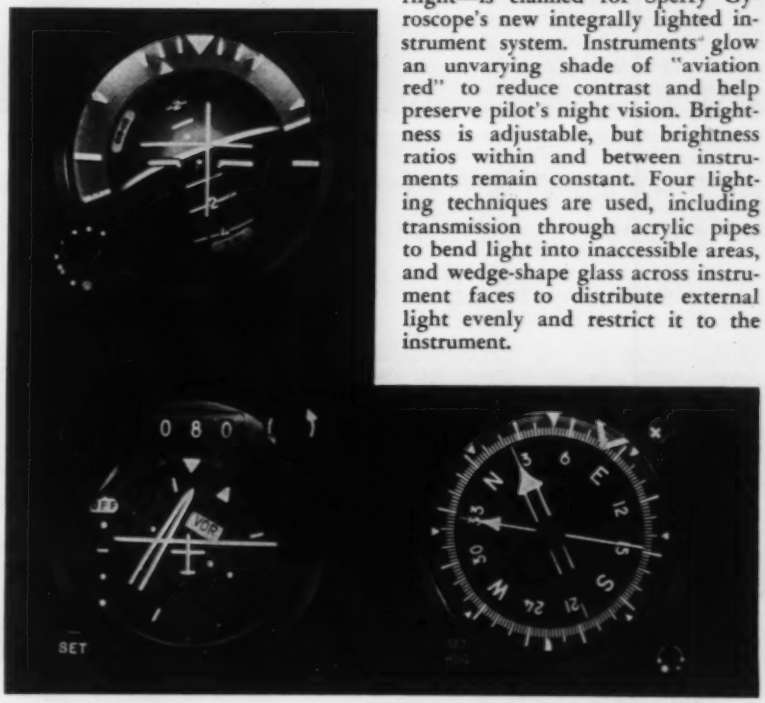
PITTSBURGH—Scientists have put the Hall effect, first discovered in 1879, to work in a commercially usable circuit element, called a Hall generator. Using two semiconductor materials, the element is essentially a solid-state multiplying device that

(*Please turn to Page 46*)



New computer element voltage V_H is proportional to the product of current and magnetic flux density. The control current is at right angles to the magnetic field

NEW LIGHT ON FLIGHT, providing optimum readability under all possible visibility conditions — daylight, twilight, night, and instrument flight—is claimed for Sperry Gyroscope's new integrally lighted instrument system. Instruments glow an unvarying shade of "aviation red" to reduce contrast and help preserve pilot's night vision. Brightness is adjustable, but brightness ratios within and between instruments remain constant. Four lighting techniques are used, including transmission through acrylic pipes to bend light into inaccessible areas, and wedge-shape glass across instrument faces to distribute external light evenly and restrict it to the instrument.



Introducing the revolutionary new MAC 4-way

DUAL-

Feature spool-within-a-spool design . . . operate with unmatched efficiency . . . sell for about half the price of most other ½" to 1¼" valves . . . meet all J.I.C. specifications

Designed around a revolutionary spool-within-a-spool, here are air valves the industry has long needed and wanted.

They are tops for performance—operating at speeds equal to any known usage—with shorter stroke, direct operation and a highly efficient *circular* air flow.

Also they operate on the *low current requirements of minimum amplified circuits*—needing just .8 amperes of inrush current.

The valves are compact, too. They are about one-half the size of similar-use competitive valves (½" to 1¼") . . . sell at about half the price in single-solenoid models. You save even more in the double-solenoid models.

There are other savings. Fewer parts and simple design reduce maintenance. Integral conduit boxes connected by wiring duct permit optional wiring. Plug-in lead connectors speed up installation. The MACsolenoid—which operates up to *30 million cycles* without appreciable wear—shaves replacement costs to a minimum.

Check the other advantages at the right. Then contact a MAC representative or write direct for all details. The 4-Way Dual-Spool air valves are now available in ½", ¾", 1" and 1¼" pipe sizes. They are quality built throughout . . . meet or exceed *all* J.I.C. standards . . . are fully tested and guaranteed.

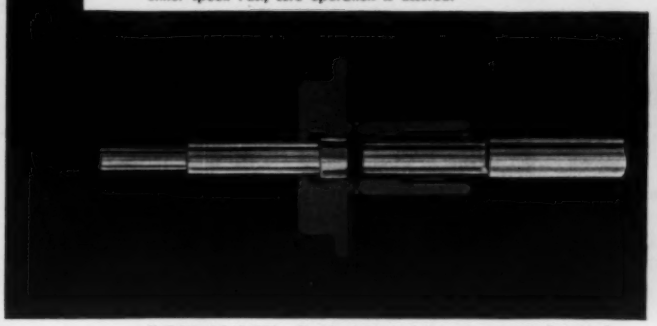
Pat. applied for on all valve features ©MAC

SPOOL

CIRCULAR-FLOW AIR VALVE

SPLIT-SECOND OPERATION—In MAC's exclusive Dual-Spool design, the inner spool operates through the core of the larger outer spool. The MACsolenoid energizes the inner spool, releasing compressed air to activate the outer spool. There is no lag between movement of either spool. Fast, sure operation is assured.

MACSOLENOID CONTROLLED—The Dual-Spool's proved MAC-solenoid has new waterproof plug-in wire lead connectors that are not rigid-mounted . . . thus are vibration-proof. The solenoid and cover assembly detach in seconds without tools. Valve is electrically inoperative with the cover off. Tests at better than 600 cycles per minute.



SHOCK PROTECTED—The shock load of the main spool is dissipated through "shear"-loaded floating heads located at spool ends. The rubber cushions soften the impact, lengthen valve life.

CIRCULAR AIR FLOW—In above double-image photograph, air space is illustrated: air circulates more freely, unhampered by right-angle turns. Valve provides full air flow throughout rated capacities.

MECHANICAL AIR CONTROLS, INC. MAC 10030 Capital, Oak Park, Detroit 37, Michigan

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Circle 422 on Page 19

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For

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- **CORROSION RESISTANCE**
- **NON-MAGNETIC PROPERTIES**

. . other special requirements

ALL SIZES, standard and special, from 1/64" to 12" or more, depending on material.

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ITI
PRECISION BALLS AND
SPECIAL ANTI-FRICTION BEARINGS

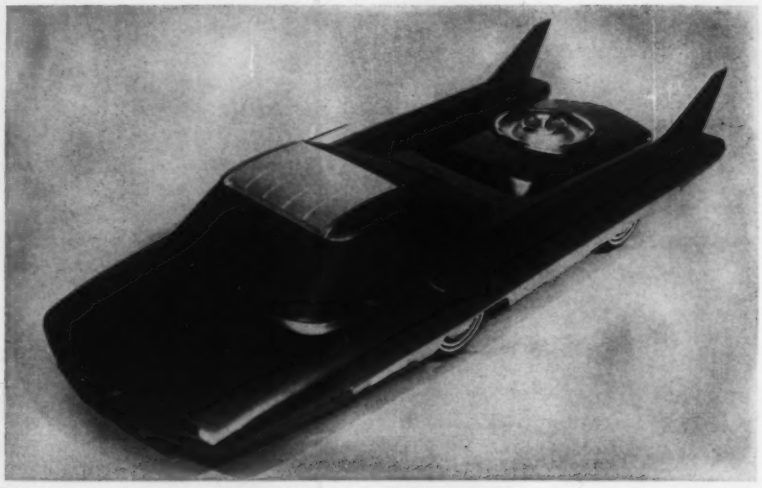
Circle 423 on Page 19

(*Continued from Page 43*)

produces an output voltage proportional to the product of two electrical quantities: the current passing through it, and the magnetic field perpendicular to it.

Developed at Westinghouse Electric Corp., the unit may find use as an analog computer element to multiply two electrical quantities. One of these would be expressed as a current, the other as a magnetic field.

Generator outputs of ½ v have been easily obtained with magnetic fields of 5 kilogauss and control currents of ½ amp. Output impedance can be adjusted from 0.01 to 20 ohms with maximum frequency response ranging from 10^7 to 10^8 cps.



NUCLEON, developed by Ford advanced stylists, shows possible styling influence of atomic power in automobiles. Replaceable power package envisioned for this model would permit driver selection of horsepower rating. Temperatures in the passenger compartment would be regulated electronically, making possible the use of fixed windows. Slit beam horizontal headlights (two only) and retractable bumpers are styling and safety features.

Meetings

AND EXPOSITIONS

May 1-8—

American Society of Tool Engineers. Tool Show to be held at Convention Center, Philadelphia. More information can be obtained from society headquarters, 10700 Puritan Ave., Detroit 38, Mich.

May 6-9—

Western Joint Computer Conference to be held at the Ambassador Hotel, Los Angeles. Sponsors are American Institute of Electrical Engineers, Association for Computing Machinery, Institute of Radio Engineers, National Joint Computer Committee. Further information is available from Mr. R. E. Utman, Electrodata Div., Burroughs Corp., 460 Sierra Madre Villa, Pasadena, Calif.

May 7-17—

World Trade Fair to be held at the Coliseum, New York. Additional information can be obtained from exposition headquarters, 331 Madison Ave., New York 17, N. Y.

May 12-15—

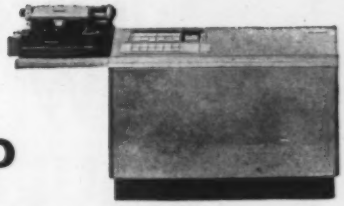
American Society of Mechanical Engineers. Oil and Gas Power Conference and Exhibit to be held at the Bellevue-Stratford Hotel, Philadelphia. Additional information is available from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

May 12-16—

American Society for Metals.

TODAY'S GREATEST VALUE IN ELECTRONIC COMPUTERS!

ROYAL PRECISION LGP-30



Compare it, feature by feature, with the other computers in its class

Feature	Computer A	Computer B	Computer C	Computer D	LGP-30	
Memory Size	220 words for data only	2160 words	1000 or 2000 words	84 words for data only	4096 words for data & program (either or both)	LARGEST CAPACITY IN ITS CLASS
Max. Speed Add Multiply	 20/sec. 4/sec.	 Comparable to LGP-30	 Comparable to LGP-30	 3/sec. 1/sec.	 Over 440/sec. Over 50/sec.	SPEED EQUAL TO MANY ROOM-SIZED COMPUTERS
Size	17 sq. ft.	6.5 sq. ft. plus table for typewriter.	45 sq. ft.	9.2 sq. ft. plus table for typewriter & control unit.	11 sq. ft.	COMPACT, DESK-SIZED, COMPLETELY MOBILE
Input-Output	Keyboard only — tape at extra cost.	Independent tape preparation at extra cost.	Extra cost peripheral equipment required.	Tape and typewriter for numerical input-output only. Independent tape preparation at extra cost.	Tape typewriter for alpha-numeric input-output standard equipment.	DELIVERED COMPLETE. NO ADDITIONAL EQUIPMENT NEEDED TO PREPARE DATA, PROGRAM OR REPORTS
No. of tubes	165	450	2,000	248	113	FEWER COMPONENTS MEAN LESS MAINTENANCE, FEWER CHECKOUTS
Voltage	220 V	110 V	220 V	110 V	110V	PLUGS INTO ANY REGULAR WALL OUTLET
Power	2.5 KW	3.0 KW	17.7 KW	1.65 KW	1.5 KW	NO SPECIAL WIRING OR AIR-CONDITIONING REQUIRED
Ease of programming & operation	Not alpha-numeric. No internal program storage.	Alpha-numeric at extra cost. 8 part instruction. Requires computer specialist.	Alpha-numeric at extra cost. Requires computer specialist.	Not alpha-numeric. No internal program storage.	Alpha-numeric. Complete internal program storage. Standard typewriter keyboard. Simplest command structure of all.	EASY TO PROGRAM AND OPERATE.
Cost Sale Rental	 $38,000 $1000/mo.	 $49,500 $1485/mo.	 $205,900 $3750/mo. up	 $55,000 $1150/mo.	 $49,500 $1100/mo.	LOWEST COST EVER FOR A COMPLETE GENERAL PURPOSE COMPUTER

Nation-wide sales and service. Trained staff of applications analysts. Library of subroutines available, plus programs for wide variety of applications.

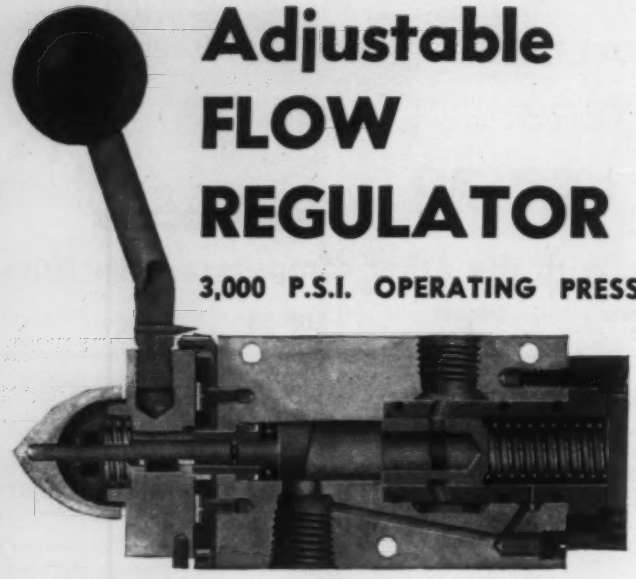
For further information and specifications on Royal Precision LGP-30, call your nearby Royal McBee office, or write Royal McBee Corporation, Data Processing Division, Port Chester, N. Y.

ROYAL McBEE

WORLD'S LARGEST MANUFACTURER OF TYPEWRITERS AND MAKERS OF DATA PROCESSING EQUIPMENT

Adjustable FLOW REGULATOR

3,000 P.S.I. OPERATING PRESSURE



MODEL 1407 Series

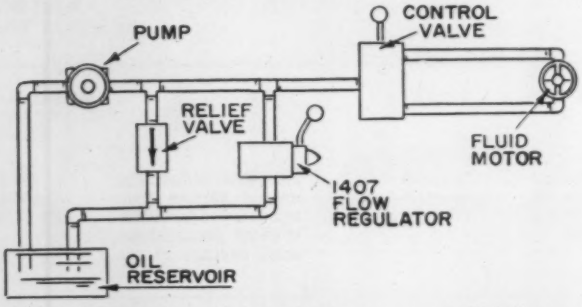
New applications and economical methods of controlling fluid motors and cylinders has prompted our company to design a full range adjustable flow regulator.

Ordering Data

MODEL NO.	MINIMUM	MAXIMUM
	FLOW IN G. P. M.	
1407 R-4-12	0.5	12
1407 L-4-12	0.5	12
1407 R-4-20	0.5	20
1407 L-4-20	0.5	20

R RIGHT HAND—Clockwise rotation from closed to open facing control handle.
L LEFT HAND —Counter clockwise rotation from closed to open facing control handle.

PROBLEM: To control fluid motor at constant speed.



Model 1407 regulator is a pressure compensated full range adjustable regulator that will maintain constant flow regardless of pressure or load changes. Circuit above allows operation at a pressure equal to load pressure on motor. Speed of motor is controlled by regulating by-pass to reservoir.

WRITE FOR SHEET 1.04

Other Waterman products:

- **Solenoid Valves**
- **Check Valves**
- **Unloading Valves and Filters**

WATERMAN
ENGINEERING COMPANY

725 CUSTER AVENUE **EVANSTON, ILLINOIS**

First Southwestern Metal Exposition and Congress to be held at the Automobile Bldg., State Fairgrounds, Dallas; technical sessions will be held at the Statler-Hilton Hotel and the Texas Hall of State at the Fairgrounds. Additional information can be obtained from ASM headquarters, 7301 Euclid Ave., Cleveland 3, Ohio.

May 14-16—

Society for Experimental Stress Analysis. Spring Meeting to be held at the Hotel Manger, Cleveland. Further information is available from the society, P. O. Box 168, Cambridge 39, Mass.

May 19-23—

American Foundrymen's Society. 1958 Foundry Show will be held in conjunction with the AFS Castings Congress at the Public Auditorium, Cleveland. Further information is available from society headquarters, Golf and Wolf Roads, Des Plaines, Ill.

May 26-27—

American Institute of Electrical Engineers. Ninth Annual Appliance Technical Conference to be held at Hotel Morrison, Chicago. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

May 26-30—

National Packaging Exposition to be held at the Coliseum, New York. Concurrently, 27th National Packaging Conference of the American Management Association will be held May 26-28 at the Hotel Statler. Further information can be obtained from AMA headquarters, 1515 Broadway, New York 36, N .Y.

June 9-13—

National Materials Handling Exposition to be held at the Public Auditorium, Cleveland. ASME-sponsored Materials Handling Conference will be held concurrently. Further information can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Circle 425 on Page 19

Circle 426 on Page 19→

GUARANTEED PURITY!

Argon of 99.995% minimum purity Guaranteed by LINDE!

The inert argon welding gas you get from LINDE is now *guaranteed** to contain *less than 50 parts per million* of impurities. And it's LINDE's regular industrial argon—not a special, extra-cost grade. You get this extremely high purity *on delivery* to you, regardless of the way the argon is delivered.

LINDE's 50 years of experience in producing gases of extremely high purity make this assurance possible. You can depend on LINDE *consistently* for the highest possible purity in the gases you use. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. *In Canada:* Linde Company, Division of Union Carbide Canada Limited.

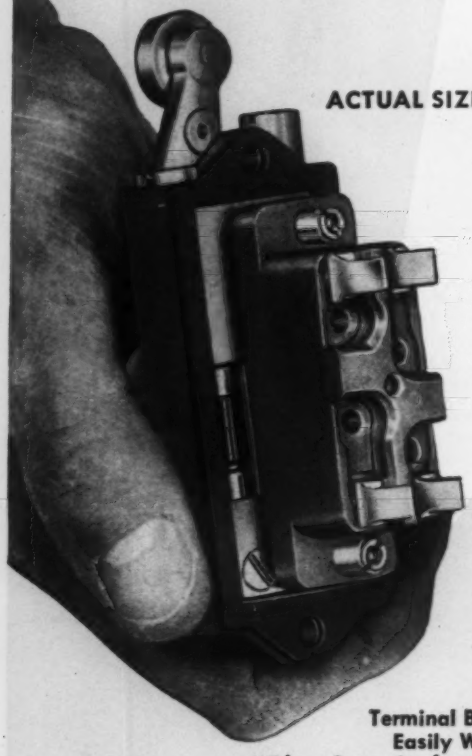
*LINDE argon delivered as a liquid is the purest inert gas on earth. Guaranteed to contain less than 50 parts per million of impurities, LINDE liquid argon contains, on the average, less than ½ of this amount and practically no moisture.

For Argon of guaranteed highest purity . . . call LINDE!

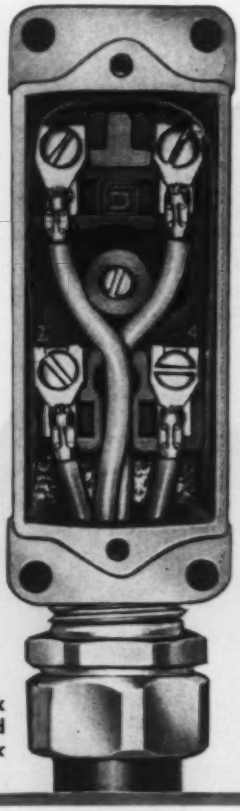
The terms "Linde" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

This New PLUG-IN LIMIT

CLASS 9007, TYPE AW



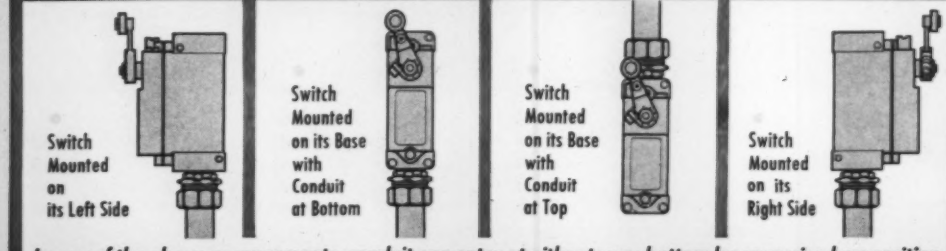
ACTUAL SIZE



Terminal Block Easily Wired
Without Removing from Box

- Oil-tight construction
- Switch plugs in—in seconds
- Mounts without disassembly
- Wired without removing from box
- Reversible plug-in unit —can be plugged-in with roller arm at either end
- Switch action can be reversed by simple screwdriver adjustment
- Present installations easily converted to plug-in
- Precision switch mechanism —only 5° to operate— 25°overtravel in either direction
- Graduated markings around hub of roller arm simplify accurate settings
- Same price as standard Square D oil-tight limit switch

6 MOUNTING ARRANGEMENTS...WITH 1 DEVICE!


Switch Mounted on its Left Side
Switch Mounted on its Base with Conduit at Bottom
Switch Mounted on its Base with Conduit at Top
Switch Mounted on its Right Side

In any of the above arrangements, conduit can enter at either top or bottom by reversing box position

EC&M HEAVY INDUSTRY ELECTRICAL EQUIPMENT...NOW A PART OF THE SQUARE D LINE

SQUARE D COMPANY

SWITCH is *SO EASY* to Use!

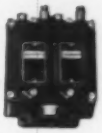
SQUARE D LIMIT SWITCHES ARE *Designed* TO DO HUNDREDS OF JOBS — BETTER!

SMALL OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE AW

Surface mounting, roller arm operated

Flush mounting, push rod operated

Surface mounting, push rod operated

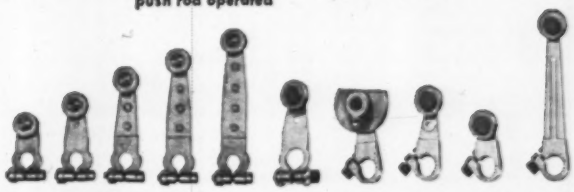


Duplex switch, surface mounting, push rod operated

Duplex switch, flush mounting, lever arm operated

Flush mounting, lever operated

ROLLER ARMS AVAILABLE IN WIDE RANGE OF DESIGNS AND LENGTHS...



HEAVY-DUTY OIL-TIGHT LIMIT SWITCH -- CLASS 9007, TYPE T

Continuously adjustable lever arms, up to 80° overtravel

Transparent plastic cover available for instant inspection

Eleven contact arrangements in one switch; only a screwdriver is required

Rear shaft design for inaccessible locations

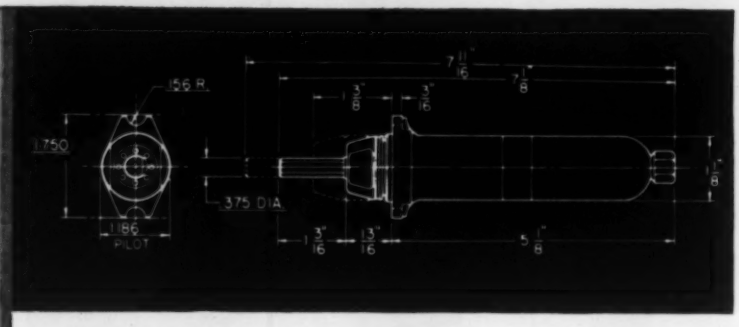
Many sizes and types of operating arms

WIDE VARIETY OF BASE PLATES AND MOUNTING HOLES...

Write for BULLETIN 9007 AW to Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin

D D D D D D D

NEW Gardner-Denver Rotary Air Motor—packaged power for fractional hp. needs



Horsepower—⅛

Stall torque—36 in.-lb.

Length—7⅛"

Diameter—1¾"

Weight—less than a pound

Three basic speeds—20,000, 5000, 1000 rpm.

Mounting—two-bolt

Lubrication—oil mist from air line lubricator

Variable speed-torque control

Here's a brand-new rotary air motor, designed by Gardner-Denver specifically for operations that require up to ⅛ hp. built into a limited space or close quarters . . . and ones that require light weight for portability.

If your design calls for dependable power in a small space, ask your Gardner-Denver representative for a demonstration of *new packaged power*—the new No. 1 rotary air motor. Or write for Bulletin 71-21.

BIG FEATURES IN A SMALL PACKAGE

Compact design ⅛ hp. packed in a unit only 7⅛" long and 1⅛" in diameter eliminates any problem in close-quarter installation. (Diameter only 1¾" at the mounting lugs.)

Quick starts and stops The new No. 1 air motor starts and stops quickly . . . gives positive control at all times without motor damage.

Can't burn out Air motors can't burn out—even when run to a stall. Stalling does not impair the motor in any way.

No spark hazard Maximum safety under hazardous conditions. Explosive dust and fumes can't be activated by air motor operations.

Continuous operation Hours of continued operation won't harm this power unit. Maintenance is kept at a minimum.

Rugged construction Cage-type gearing and oversized idlers in geared models are two of many construction features which assure long life and maximum utility.

New No. 1 air motor specifications:

Size No.	Max. Output Hp.	Max. Output Rpm.	Free Speed Rpm.	Stall Torque (In.-lb.)	Gear Ratio	Max. Overhung Load on Spindle at Stall	Weight (Lb.)	Air Used at Max. Output (Cu. Ft. Free Air)
71A-1200	⅛	9000	20,000	2	Direct	170	¾	10
71A-150	⅛	2375	5000	8	4.6:1	170	¾	10
71A-110	⅛	475	1000	36	21.2:1	170	⅞	10

ENGINEERING FORESIGHT—PROVED ON THE JOB
IN GENERAL INDUSTRY, CONSTRUCTION, PETROLEUM AND MINING

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 428 on Page 19

NEW

OHMITE®

"TAN-O-MITE®" TANTALUM CAPACITORS

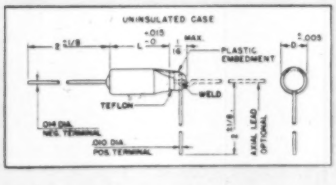
HIGH STABILITY
FOR —55°C to + 85°C OPERATION
HIGH CAPACITANCE
SUBMINIATURE SIZES
LONG SHELF LIFE

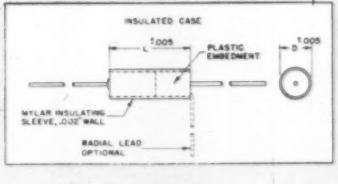
SERIES TW WIRE-TYPE TANTALUM CAPACITORS

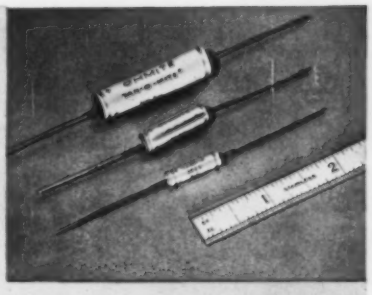
These new subminiature, wire-type units feature greater capacitance per unit volume, lower leakage current and power factor, and small capacitance drop at extremely low temperatures as compared to other types of electrolytics. Ultrasmall for low-voltage DC transistorized electronic equipment, these new tantalum capacitors have *high stability, high capacitance, long shelf life, and excellent performance* under temperature extremes of—55°C to + 85°C. Available in eight subminiature sizes; 0.1 to 80 mfd. over-all capacitance range.

SIZE	UNINSULATED		INSULATED	
	D (inches)	L (inches)	D	L
*T	.075 (5/64)	.156 (5/32)	.082	.203
*S	.075 (5/64)	.187 (3/16)	.082	.234
*M	.095 (3/32)	.172 (11/64)	.100	.218
*A	.095 (3/32)	.250 (1/4)	.100	.312
*B	.125 (1/8)	.312 (5/16)	.134	.375
C	.125 (1/8)	.500 (1/2)	.134	.562
D	.125 (1/8)	.625 (5/8)	.134	.687
E	.125 (1/8)	.750 (3/4)	.134	.812

Smallest size is .075 (5/64) x .156 (5/32) inches; the largest is .125 (1/8) x .750 (3/4) inches. Five stock sizes (*) are available in a wide range of capacitances and voltages. Units insulated with a tough Mylar® plastic sleeve can be furnished. *Write on company letterhead for Bulletin 148B.*







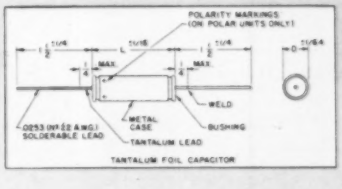
SERIES TF FOIL-TYPE

These capacitors are tantalum foil, electrolytic units designed for low voltage AC and DC applications where small size, top performance, and stability of electrical characteristics are required. Units feature unusually long shelf and operating life.

CASE SIZE	D*	L*
J	3/16"	11/16"
K	9/32"	7/8"
L	3/8"	1 3/16"

**Add 1/64" to L and 1/32" to D when insulating sleeve is used.*

Three sizes now available; .25 to 140 mfd. over-all capacitance range. Standard tolerance is ±20%. Working voltage up to 150 volts. Polar and nonpolar units are available. *Bulletin 152.* Design and construction meet military specification MIL-C-3965, paragraph 3.3.



OHMITE® QUALITY Components

RESISTORS • RELAYS • TAP SWITCHES
RHEOSTATS • TANTALUM CAPACITORS
VARIABLE TRANSFORMERS

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois

Circle 429 on Page 19

120,000 of these detonator plugs

equal

one 73 lb. bumper strip

both are products of

ORCO

CUSTOMEERING

The precision pigmy component weighs less than 3/10 of a gram and is an important part of a delicate detonator assembly. The 73-lb. bumper strip is a protective part of a "Dodgem" car in amusement parks.

Big difference in size and application? Sure, but Ohio Rubber is recognized as a producer of "customeered" parts made from rubber, synthetic rubber, silicone rubber, polyurethane, and flexible vinyl, in *all sizes,* for any application, and whether molded, extruded, or bonded to metal.

From design through electronically controlled compound mixing and production facilities in four plants, Ohio Rubber's integrated set-up is prepared to handle your most exacting rubber and vinyl component requirements. Let ORCO engineers help on your next problem. See how ORCO CUSTOMEERING can work to your greater advantage.

Send for free booklet "Component CUSTOMEERING rubber and vinyl parts."

THE OHIO RUBBER COMPANY

A Division of The Eagle-Picher Company
Willoughby, Ohio

Circle 430 on Page 19

(Advertisement)

Technical data for gasket design and selection

NUMBER TWO

Effective sealing with confined gaskets

To seal a metal-to-metal joint effectively, a gasket must completely fill the gasket channel to provide maximum contact with the mating flange . . . and it must compress enough to prevent leakage of the sealed medium.

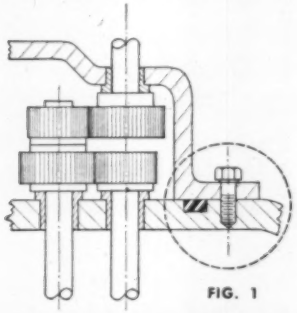


FIG. 1

With truly compressible materials, such as cork-and-rubber composition, gaskets are cut to full channel width, and from 1.25 to 1.5 times channel depth. No relief for sideflow is needed, and close tolerances for gasket and metal are unnecessary.

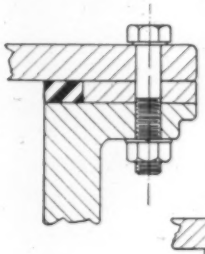


FIG. 2

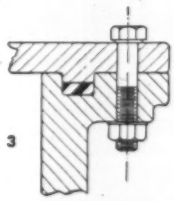


FIG. 3

In Figure 1, the instrument housing flange employs a completely confined cork-and-rubber gasket that prevents lubricant leakage and permits perfect alignment of gears.

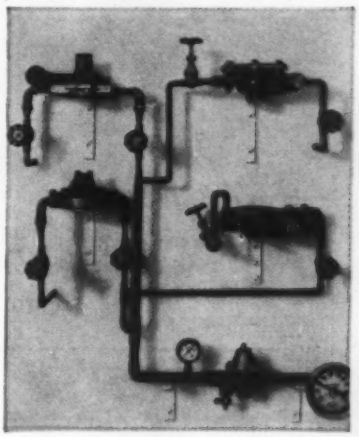
In Figure 2, an annular shim adapts flat flanges to metal-to-metal sealing. Cork-and-rubber gasket compresses to form a tight seal without flowing out of position.

Figure 3 shows a high-pressure metal-to-metal flange with a stop to prevent blowouts. Cork-and-rubber completely fills the confined channel.

Comparison testing of fiber gasket materials under simulated service conditions

Testing gasket materials under simulated service conditions can take much of the guesswork out of field evaluation. The saving in time and expense can be considerable.

A good example of such testing is the device shown here which was developed by Armstrong engineers to study the behavior of fiber gasket materials.



The apparatus consists of four different stock automotive water pumps connected to a common source of fluid. It can be used to measure a large number of variables that affect gasket performance.

Four different gasket materials can be checked simultaneously under identical conditions on these pumps; or the sealing efficiency of different gauges of the same material can be measured.

The effectiveness of gasket materials at various flange loadings can also be determined, as well as comparative data on torque retention characteristics of the materials.

Temperature, pressure, and the contained fluid can also be varied. Usually, testing is done at 180° F. to 200° F., under 25 psi, using water or a 50/50 solution of water and ethylene glycol. The fluid can be kept in constant circulation, or locked in the individual pumps.

Although this apparatus was specifically designed to study sealing of automotive water pumps, the problems are common to those encountered in other equipment where sheet fiber gaskets are used. As a result, data obtained in the water-pump tests can be rather generally applied to other applications where operating factors are similar.

These tests indicate that many of the leaks encountered in automotive water pumps are caused by leaching and extraction of binder from conventional glue-glycerine saturated materials.

These problems can be eliminated with Armstrong Accopac beater-saturated fiber materials. The latex binders in Accopac compositions cannot be extracted by water or ethylene glycol, thus eliminating shrinkage and leakage.

For your free copy of this new gasket materials booklet, write Armstrong Cork Company, Industrial Division, 7104 Dean Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

Circle 431 on Page 19

Now available—
Brainard tube in beautifully embossed Sharonart finishes.

She's sitting on top of a great idea.....

Welded Steel Tube with a beautifully embossed finish is now available from Brainard Steel. Precision welded from quality Sharonart strip steel, this new tube can help you produce a mar-proof product . . . and that's not all . . . Brainard's Sharonart tube can save you money by eliminating polishing before chrome plating. Available in several designs, this unique tube can give you a product that is distinctly different.

Brainard tube is available in sizes from ½" to 4", in gauges from .028 to .120. Also available in squares, rectangles and special shapes.

For more information about Brainard's full line of steel tubing send for this all new catalogue of helpful information.

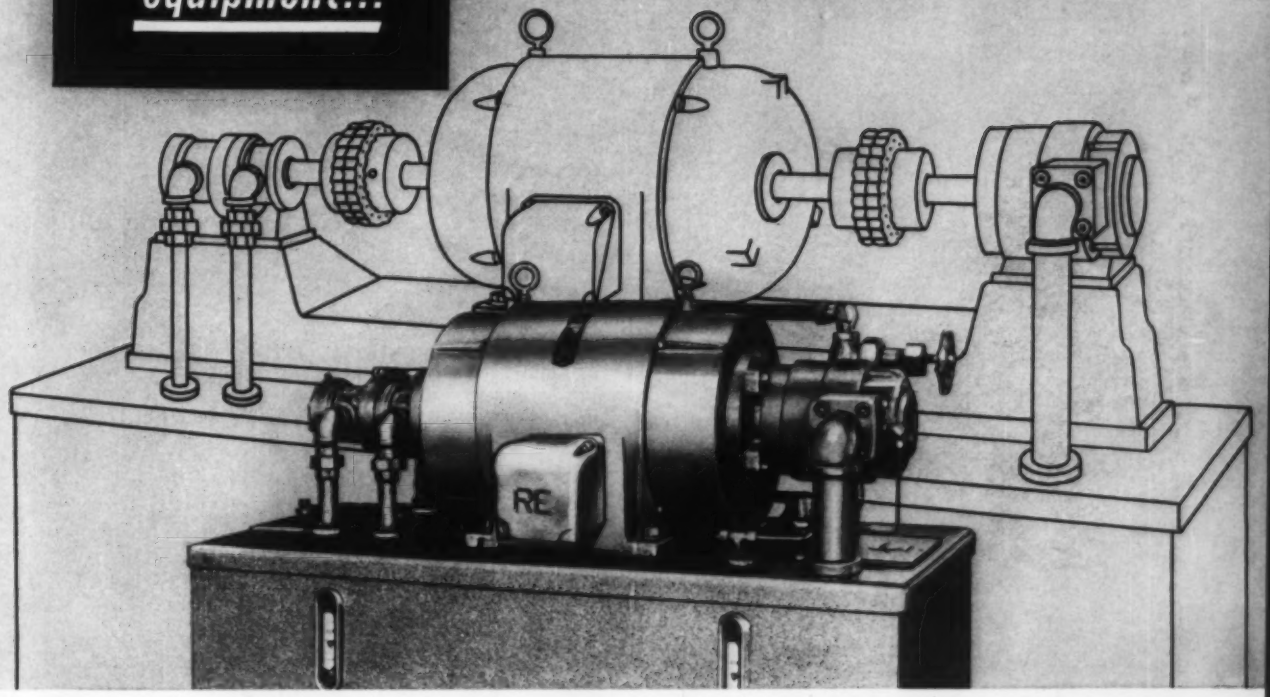
SHARONSTEEL

Brainard Steel Tubing

2192

Brainard Steel Division, Sharon Steel Corporation
Griswold Street, Warren, Ohio

If you use or sell hydraulic equipment...

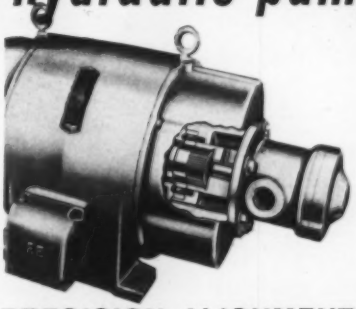


...cut space needs almost 50% with REULAND spline-coupled hydraulic pump mount motors!

Pump and motor become *one* with the new Reuland spline-coupled hydraulic pump hook-up. The pump shaft is connected directly to the motor's shaft *inside the motor*. Flexible couplings are eliminated... pump mount platforms are eliminated... and the tank length can be reduced because almost 50% less mounting area is required. Compact appearance is beautiful.

SPEEDY INSTALLATION

Pump-to-motor hook-up is merely a matter of seconds. All you do is slip the spline coupling onto the pump shaft...and attach the pump to the endbell. This spline coupling is supplied with the motor and is precision mated for each make of pump. There's no time wasted tinkering around... takes only a fraction of the ordinary time.



PRECISION ALIGNMENT

Alignment is perfect *automatically* whether the installation is made out in the field or on the production line. This permits even unskilled workmen to handle this simple task without error. Also, by hooking the pump up at the point of bearing support, within the motor, vibration is reduced to a new minimum. Operation is smooth, quiet.

COSTS LESS...SAVES INSTALLATION LABOR... FITS ALL PUMPS

The Reuland spline-coupled unit is priced lower than a conventional set-up... saves you extra money by reducing installation costs. What's more, we can supply it to fit any make of pump you may be using. So sure are we that it will be of help to you, we are offering to engineer a demonstration unit to *your* equipment, without the slightest obligation. These units are our best salesmen.

OUR NEW GENERAL CATALOG WILL COME IN HANDY—SENT FREE ON REQUEST.

MODERN POWER FOR MODERN-DAY PRODUCTS

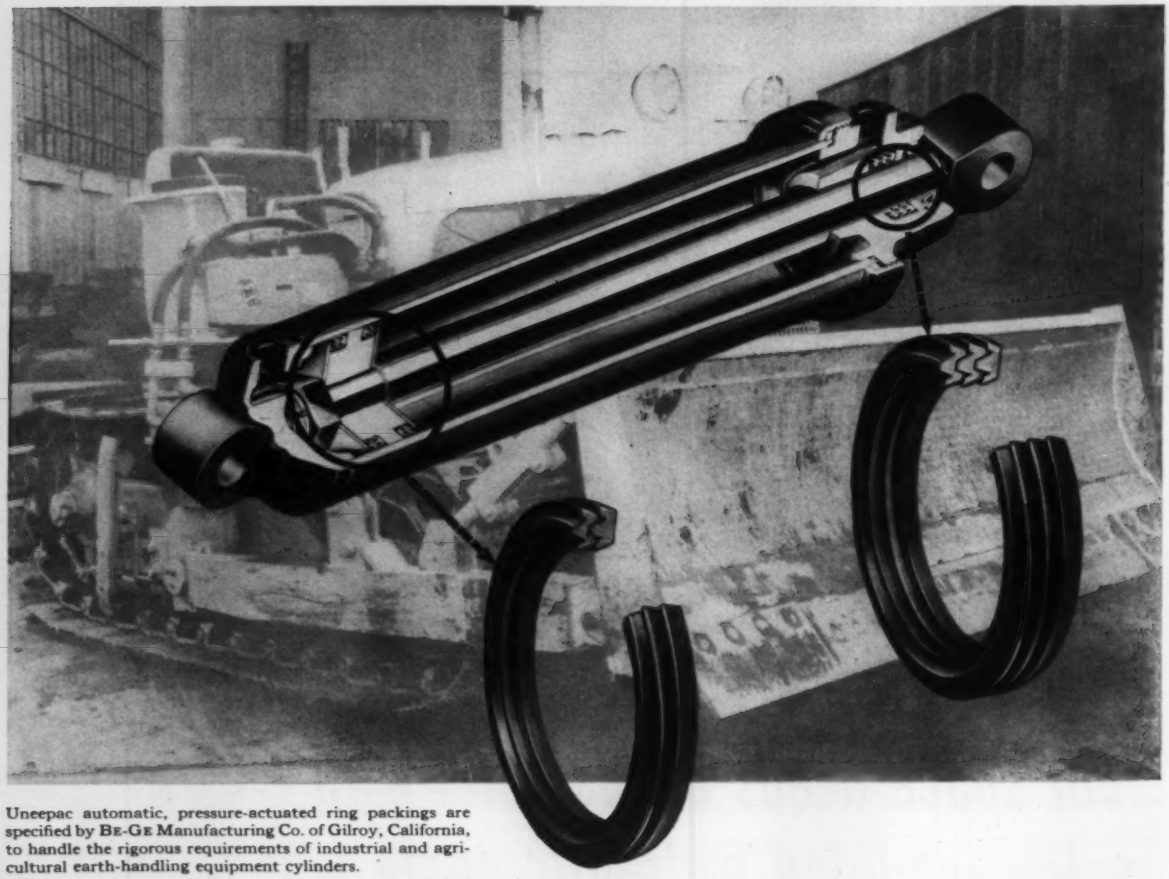
REULAND MOTORS

REULAND ELECTRIC COMPANY
WESTERN DIVISION: Alhambra, California
EASTERN DIVISION: Howell, Michigan
DISTRIBUTORS IN ALL PRINCIPAL CITIES

Circle 433 on Page 19

*Trademark Registered

Rigorous tests convinced BE-GE to use J-M Uneepac® in their rugged cylinders



Uneepac automatic, pressure-actuated ring packings are specified by BE-GE Manufacturing Co. of Gilroy, California, to handle the rigorous requirements of industrial and agricultural earth-handling equipment cylinders.

Uneepac proves it can handle shock pressures to 4,000 psi in three-year, life-test program

• BE-GE Manufacturing Company's line of cylinders for their hydraulic systems has to stand up to years of day-in, day-out abuse. That's why BE-GE engineers subjected J-M Uneepac Rod Packings to a 350,000-cycle test and Uneepac Piston Packings to a 150,000-cycle test in a three-year program that proved Uneepac can take working pressures to 2,500 psi—shock pressures to 4,000 psi. As proof of performance, Uneepac is now the specification packing on all BE-GE standard—and heavy-duty cylinders.

Pressure-actuated Uneepac Rings offer high-efficiency sealing in minimum packing depth. Each ring provides an efficient, individual seal—nests with adjacent rings in an interlocking manner without compression adjustment for true, multiple-ring action.

With Uneepac, you can achieve high-efficiency sealing with fewer rings, smaller stuffing boxes. For quick, easy installation, Uneepac rings are self-centering, self-adjusting. Make it a point to consider Uneepac Rings for every application requiring top packing efficiency and life.

Uneepac rings are available in all standard materials in a wide range of sizes for most rod and plunger applications. For further information, write to Johns-Manville, Box 14, New York 16, N. Y.

J-M Clipper Seals—used as rod wipers in BE-GE cylinders—keep dirt out.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

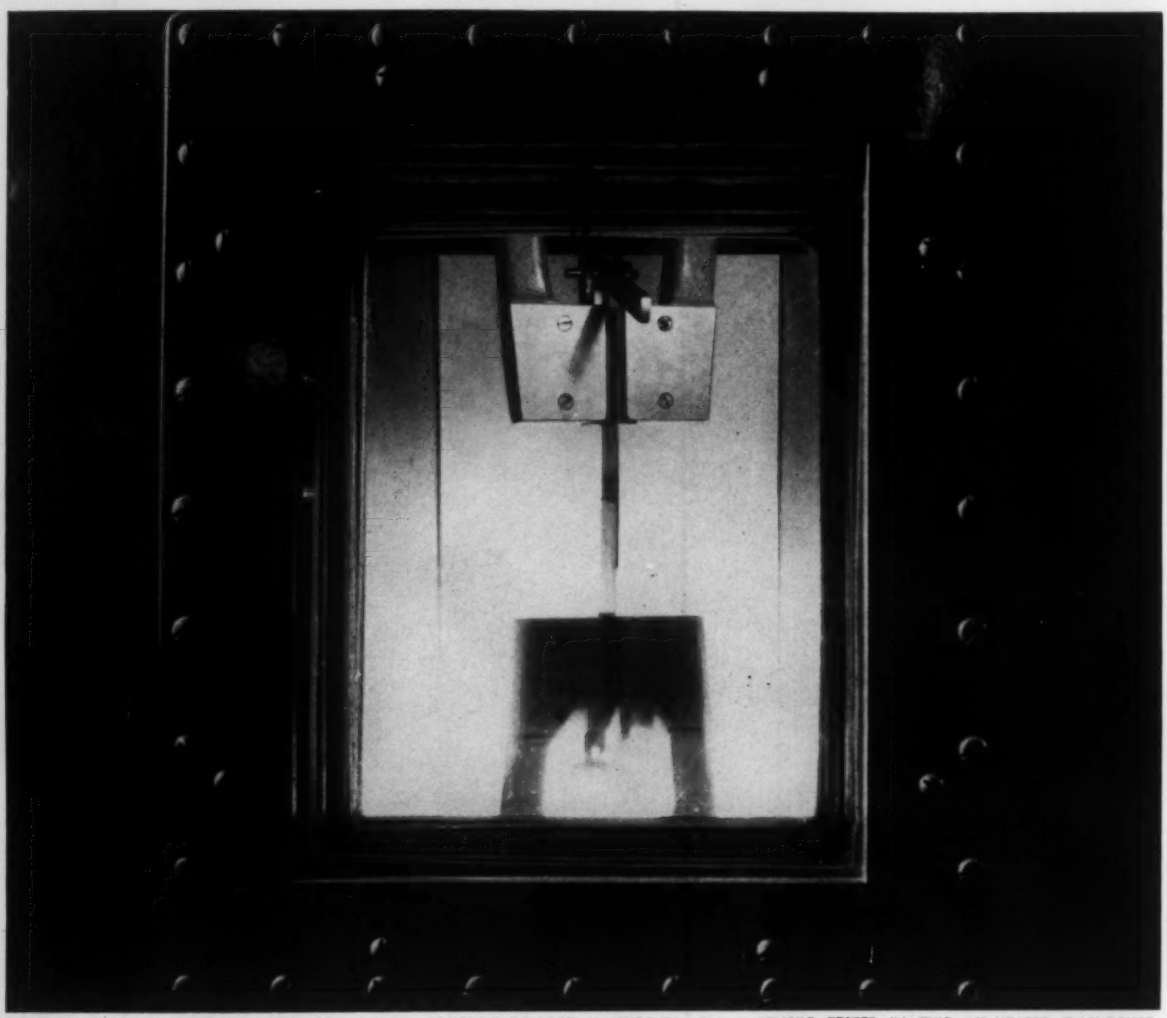
NOW standard hand socket wrench or nut-runner drives THREAD CUTTING FASTENER

Specifically designed to hold die-cast or cold-forged name plates, emblems and trim against sheet metal surfaces . . . DOT's hex-head T.C.F. can be used in many other applications which require a spring take-up fastener (with integral washer) that pulls up tight without backup on flat or contoured surfaces.

It cuts clean, deep threads on unthreaded studs, even those that are chrome plated. Used on non-vertical studs, T.C.F. accomodates itself to any angle up to 20° from the vertical . . . and, when supplied with a pre-assembled plastic sealer, makes a water-tight seal. The sealer *precedes* the fastener onto the stud so that it is not damaged by the thread-cutting process.

T.C.F. is available *in quantity*, with or without sealer, to fit 1/8", 3/16" and 1/4" studs. Detailed drawings, dimensions and prices available on request.

Rugged 3M sandwich adhesive EC-1357 holds 315 psi at 200° F.



TORTURE CHAMBER. BONDING STRENGTH OF 3M ADHESIVE EC-1357 IS CHECKED ON A TENSILE TESTER IN THIS AIR-HEATED ENCLOSURE.

The two metal strips in this tug-of-war are bonded by a tough, heat-resistant 3M sandwich adhesive—EC-1357. On the tensile tester, under a dynamic loading of ½ inch per minute . . . and at searing temperatures as high as 200° F. . . . EC-1357 withstands a stress of over 300 psi.

Rugged grip . . . you bet! But more than that, because it is dark colored, EC-1357 dries faster under infrared heat, and you cut production costs by pre-drying for maximum immediate strength—or cold-bonding on a cold press or nip roller for fabricating at room temperature.

Its remarkably high resistance to moisture, high and low temperatures, and weathering make EC-1357 ideal for installations where climatic changes are sudden and severe. And EC-1357 is easy to spray-apply. Greatly reduced cobwebbing insures better surface-wetting for far better adhesion. And you save materials!

3M also offers EC-1368, a light colored version of EC-1357 which provides the same cold-setting, high strength bond.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

For full details contact our branch sales office near you. There are 19 located in principal cities throughout the United States ready to assist you in technical problems. Six plants provide local service for faster delivery. For free illustrated literature, write: 3M Company, Dept. C-4, 417 Piquette Ave., Detroit 2, Michigan.

ADHESIVES, COATINGS AND SEALERS DIVISION

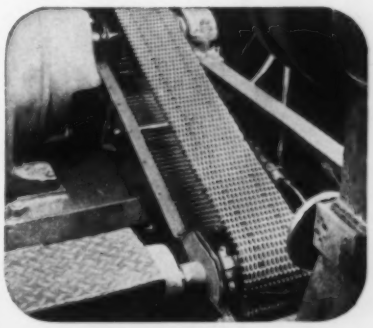
MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

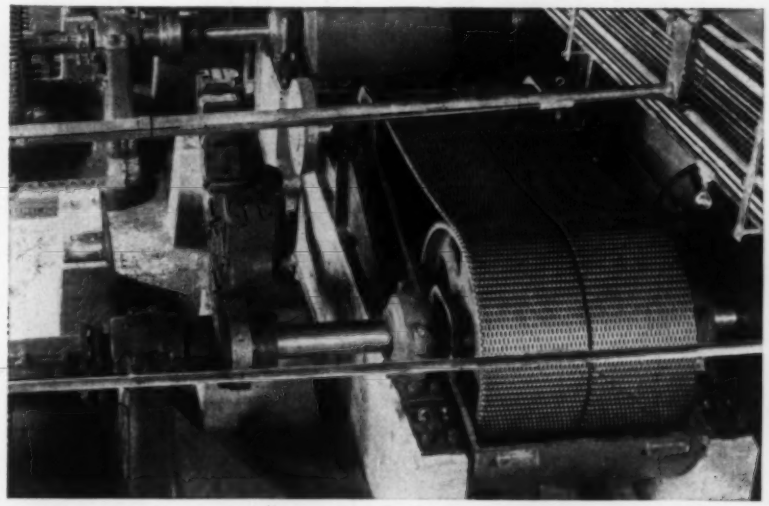
3M COMPANY

How LINK-BELT silent chain comes through industry's stiffest tests

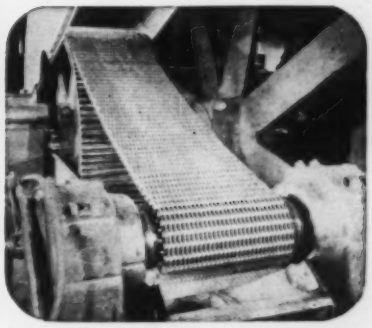
No other drive can do the same



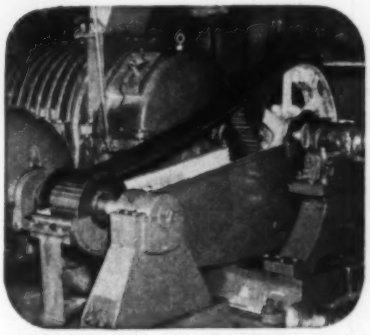
HIGH SPEED. Link-Belt silent chain drives on newspaper presses often operate at speeds of 4000 to 5000 feet per minute.



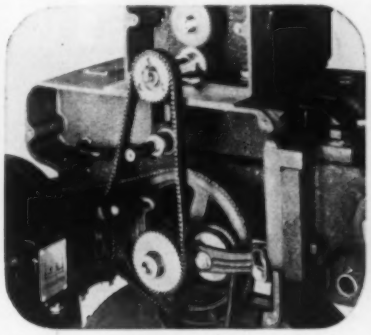
LARGE OR SMALL HP. Two 24-in. strands of Link-Belt silent chain on turbines powering 850-kw generators comprise one of the largest chain drives ever built. Silent chain provides high efficiency (over 98%) on large or fractional hp drives.



ADVERSE OPERATING CONDITIONS. Effects of heat, humidity and cold are minimized with Link-Belt silent chain drives.



LARGE RATIOS. Link-Belt silent chain operates efficiently at ratios as high as 10-to-1, with resulting space economies.



COMPACTNESS. A complete drive as small as your thumb—Link-Belt 3/16-in. silent chain is ideal for limited-space applications.

LONG LIFE. Link-Belt silent chain has given more than 30 years of uninterrupted service on ventilating systems.

Get in touch with your nearest Link-Belt office for

88-page Data Book No. 2425

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.680-A

Another new development using

B.F.Goodrich Chemical *raw materials*

HYCAR RUBBER SAYS "NO" TO FIREWATER DAMAGE

CHOOSING a material for resilient parts like seals, gaskets, and protectors in firefighting equipment poses a special problem. Water is often pumped right out of harbors and rivers—laden with oil, gasoline and other solvents.

Hycar nitrile rubber is ideal for this service because it is resistant to oils, tars and other hydrocarbons—as well as salt water. Although tough and abrasion resistant, Hycar is readily molded and extruded to make products with the desired physical properties.

Wherever the going is rough on ordinary rubber, you should investigate Hycar. For information write Dept. KK-2, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Fire-fighting equipment *valves made by Akron Brass Manufacturing Company use Hycar rubber seats made by Jet Rubber and Plastic Company, New Milford, Ohio. Hycar nitrile rubber is supplied by B.F.Goodrich Chemical Company.*

Hycar
American Rubber

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR American rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

new streamliner program... 2-day Formica shipments

Now you can count on 2-day shipment of standard grades of laminated plastics from the new Formica Streamliner stocks. You'll get faster shipment of all standard grades thanks to new inventories of "treated," or semi-processed materials which have now been set up.

Twenty-five "special purpose" grades—now offered for the first time—offer new design opportunities.

Your additional new grade requirements will be met through expanded research and development facilities now available—including Formica's new resin research laboratories and resin processing plant. Write for free copies of the new Streamliner folder and Stock List-Price List. Formica Corporation, subsidiary of American Cyanamid, 4514 Spring Grove Ave., Cincinnati 32, Ohio.

FORMICA
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Application Engineering
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FI-1774

the complete laminated plastics service

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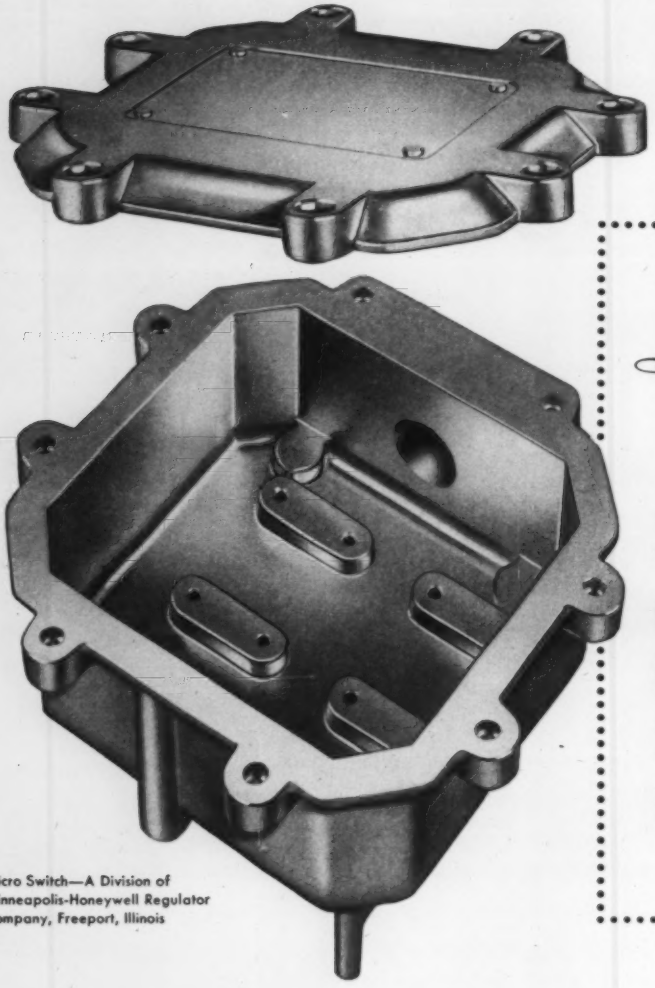
☐ Please send me.....copies of your new STREAMLINER folder and STOCK LIST.
☐ Would also like a copy of your Formica-4 booklet.

Name_____ Title_____
Company_____
Street_____
City_____ Zone____ State_____

Circle 439 on Page 19



*Micro Switch—A Division of Minneapolis-Honeywell Regulator Company, Freeport, Illinois

Lifetime Quality

with MADISON-KIPP zinc and aluminum die castings

The earmarks of lifetime quality are never elusive. They are there to see in dis-assembled, unpainted components. They are there to see in break-down tests.

The Kipp die cast body and cover of the *Micro Switch instrument here illustrated are of lifetime quality not only to encase and protect functional parts, but also to provide a rigid frame, ample bearing bosses, stable dimensions, and other last word engineering features.

The attentive mechanics at Madison-Kipp invite you to clip this ad as a reminder to contact them for close cooperation on the momentous details of design when you next have die casting requirements.

kipp

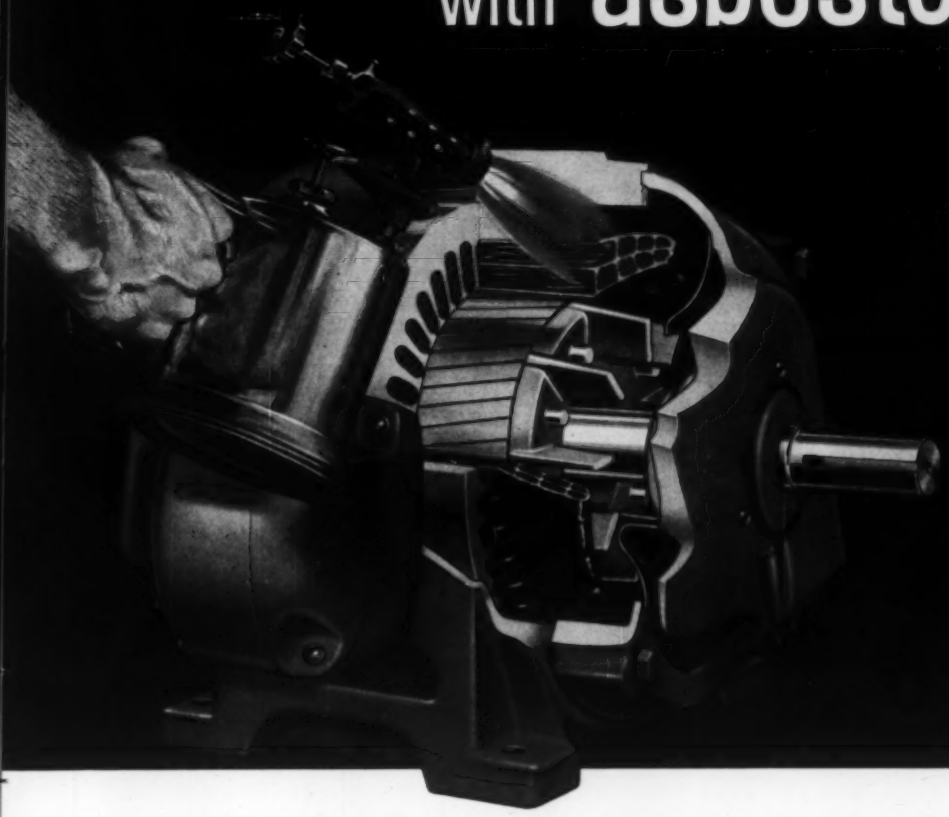
MADISON-KIPP CORPORATION
210 Waubesa Street • Madison 10, Wis., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Circle 440 on Page 19

only **U. S. MOTORS**

insulates all windings with asbestos!



your best protection

against
motor burn-out
and
production
shutdowns

Only U.S. offers this protection! ALL windings insulated with asbestos—nature's million-year-old insulating material that *cannot carbonize!* Many motor makers use varnished paper, cloth, oiled linen, press-board, fish-board—even insulating varnish alone. All these will carbonize... not one is fire-proof!

Only the original, patented U.S. ASBESTIC PROCESS—gives you: 1—*Heat resistance*... can't carbonize, 2—*heat conductance* better than any cellulose material, 3—*moisture resistance*... due to exceptional impregnation and coating of windings.

Protect yourself against costly production shutdowns due to motor burn-out! Be sure to specify: "U.S. MOTORS"!

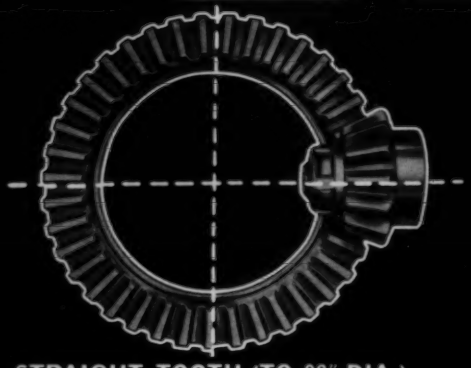
U.S. ELECTRICAL MOTORS INC.

BOX 2058, LOS ANGELES 54, CALIFORNIA
OR MILFORD, CONNECTICUT

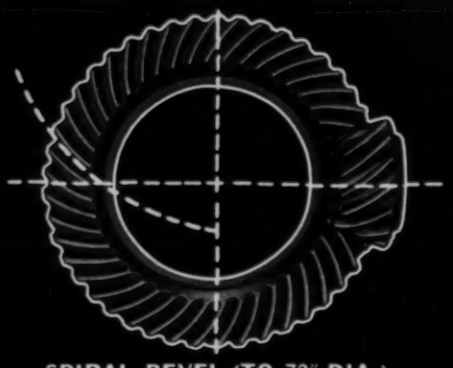
FREE COLOR-ILLUSTRATED BROCHURES
For specific data on asbestos protection, write for General and Type H Uniclosed Bulletins.

Circle 441 on Page 19

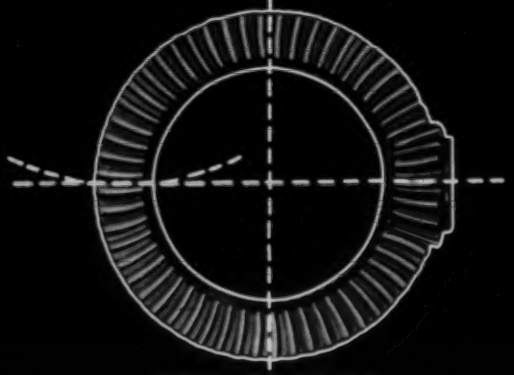
DO YOU KNOW YOUR BEVEL GEARS?



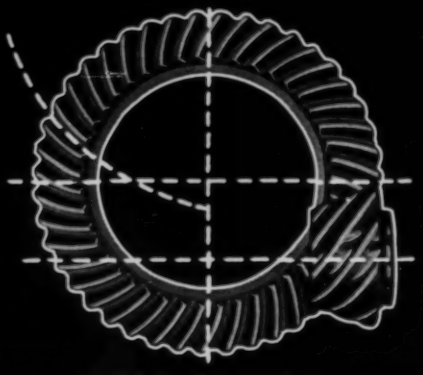
STRAIGHT TOOTH (TO 98" DIA.)



SPIRAL BEVEL (TO 72" DIA.)



ZEROL (TO 72" DIA.)



HYPOID (TO 48" DIA.)

phillie gear makes them all

Send for our 72 page "Gear Book" G-127. Please use your Business Letterhead when requesting a copy.

Phillie Gear is equipped with the "know-how", the manpower, and latest facilities to manufacture the entire family of Bevel Gearing—sizes and capacities range from the very small to the most massive sizes obtainable. Ultra Precision ground tooth Spiral Bevel Gears are available up to 23" diameter.

All types and sizes of gears produced by "Phillie" are made to the highest standards of Engineering skill and exactitude—they are the culmination of over 65 years' experience, and are produced on the very latest machines by skilled craftsmen—In a nutshell, Phillie Gear offers, not only the finest gears obtainable, but prompt and courteous service as well.

SPUR • HELICAL • SPUR INTERNAL • HELICAL INTERNAL • RACK • HERRINGBONE • WORM • NON-METALLIC • SPLINES • CONIFLEX BEVEL • SPIRAL BEVEL • ZEROL • HYPOID • INTERMITTENT • SPROCKETS • CONTRACT MACHINE WORK

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INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

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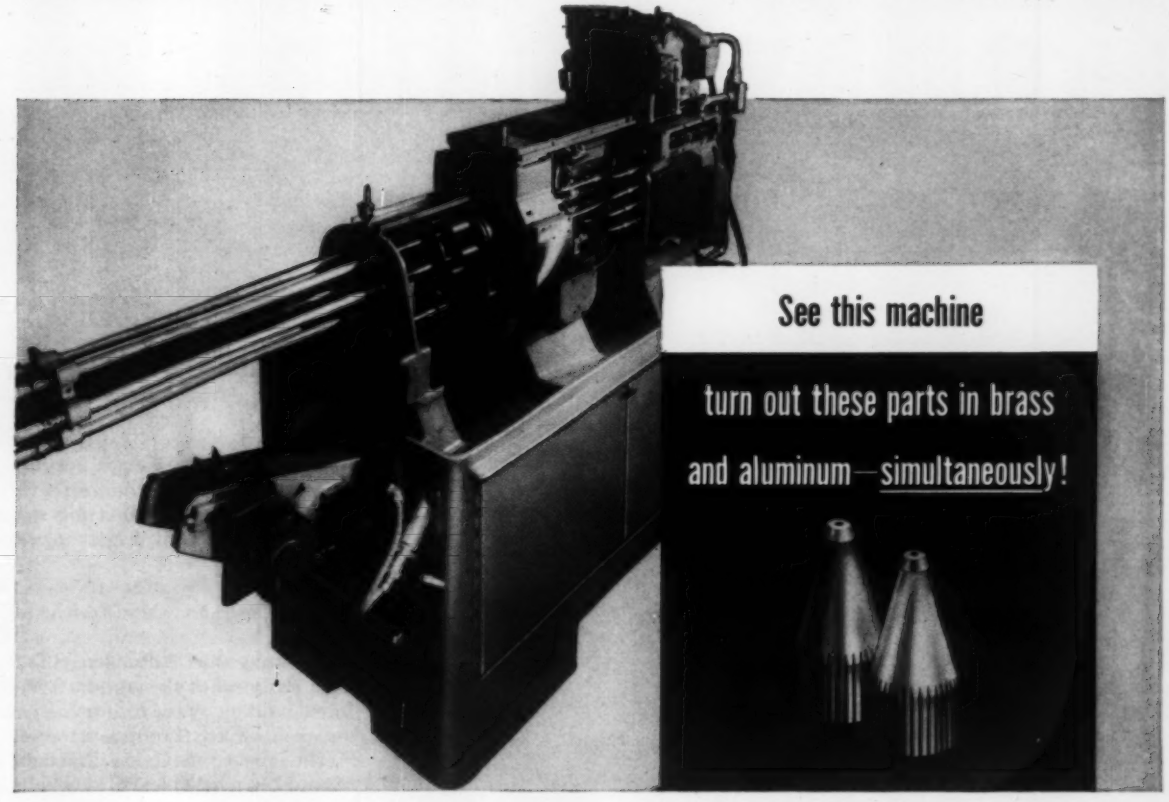
BETTER MACHINING STARTS WITH ALCOA SCREW MACHINE STOCK

Alcoa proved it in Cleveland . . . now will prove it in other cities



See screw machine parts produced in aluminum at less cost than steel or brass

When Alcoa and National Acme Company sponsored a machining demonstration in Cleveland last September, 700 design and production engineers and purchasing people saw aluminum and brass parts produced *simultaneously* on a six-spindle automatic screw machine—saw documented evidence that screw machine parts can be produced cheaper in aluminum than in brass or steel. Many expressed frank amazement at the cost comparisons shown.

Here is eye-opening machining news for all industry. Now *you* can see this demonstration, which Alcoa will sponsor in Chicago, Boston, New York*, Detroit, Los Angeles and other important centers.

If your function is design or production of products that use screw machine parts, you will find the Alcoa machining demonstration an enlightening experience. You will see how aluminum offers the ultimate in design freedom because it's so workable, so easy to machine—because it gives better finishes including anodized color. You will see the new color movie about Alcoa Screw Machine Stock, "The Four Amazing Alloys."

Send in the coupon for your invitation—and for a Design Calculator (slip-stick) for use with Alcoa® Aluminum Screw Machine Stock.

WE CHOSE ALCOA ALUMINUM SCREW MACHINE STOCK

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

*May 7, 8—Alcoa's Bridgeport Works
Atlantic Street, Bridgeport, Connecticut

Aluminum Company of America
873-D Alcoa Building, Pittsburgh 19, Pennsylvania

Yes, I want to attend the Alcoa machining demonstration nearest my area_____.

Please send my invitation—and Design Calculator.

Name_____

Position_____

Company_____

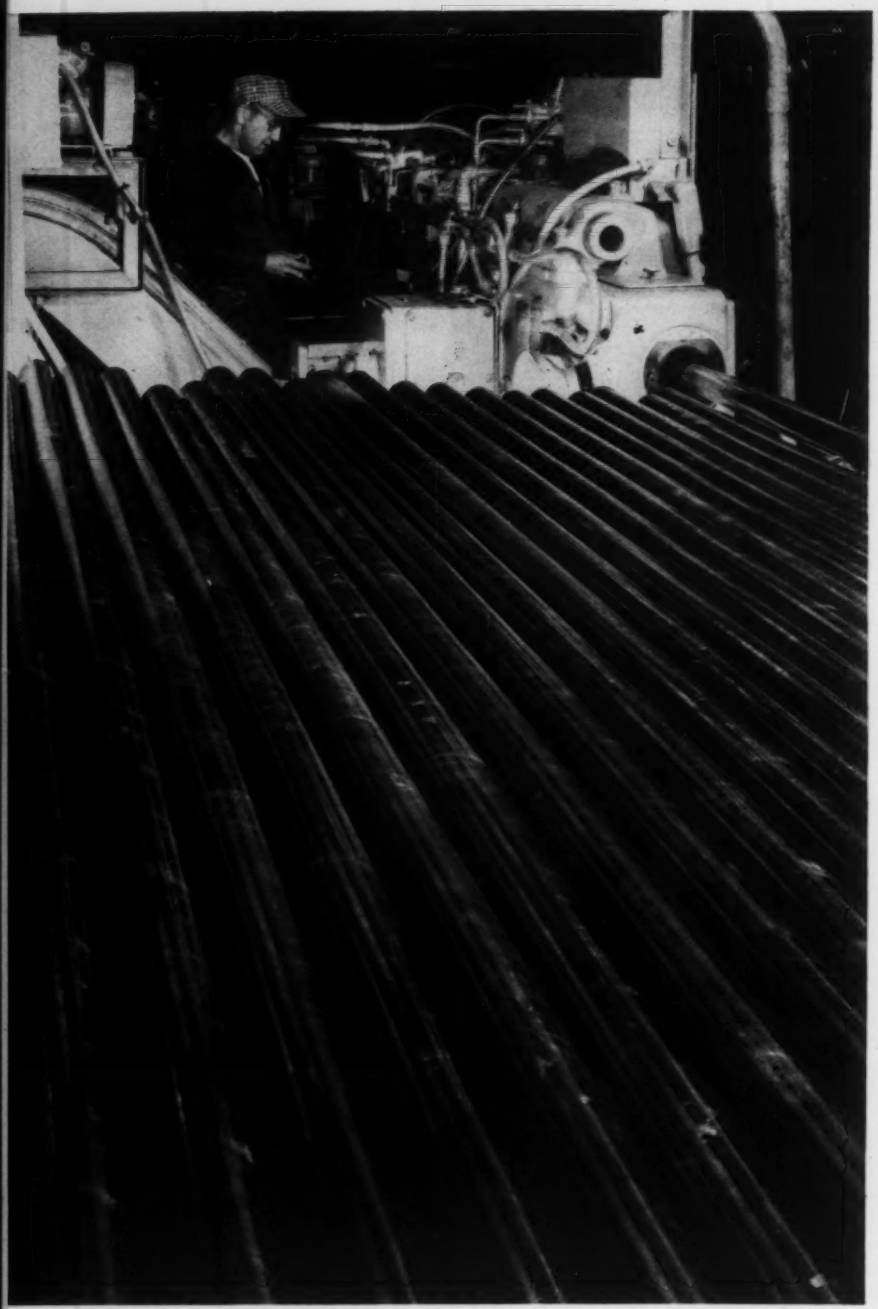
Address_____

City_____ Zone_____ State_____

Circle 443 on Page 19

(Advertisement)

Brand New Transmission in 1958 Cars Uses Pittsburgh Steel Tubes For 3 Key Parts



Here's the raw material for a critical part in a brand new automobile transmission for 1958. These seamless mechanical tubes, a product of Pittsburgh Steel Company, will be cut to size on the machine in the background and processed into shafts for grade retarders.

Developing and producing a new transmission for a leading car challenges suppliers as well as the automaker himself.

Pittsburgh Steel Company's seamless mechanical tubes successfully met such a challenge by making good on three critical parts for a new transmission making its debut in 1958 models.

Ability of Pittsburgh Steel's tubes to meet this auto manufacturer's high requirements and rigid testing assures tube users in other fields of high, uniform quality.

Tubes from the mills of Pittsburgh Steel are used for these transmission parts:

1. Convertor Reaction Shaft—This shaft takes the torque (turning force) built up by the torque convertor and transmits that torque to the gears.

The convertor reaction shaft is made of seamless mechanical tubing with an outside diameter of 2.219 inches and an inside diameter of 1.505 inches. It is cut to size, centered, given centerless grinding, heat treated and broached—or sized—to a tolerance of .001 inch. Welding and final processing follow.

2. Grade Retarder Shaft—This part is a new feature in auto transmissions. It gives cars a new driving range which improves control on steep downgrades and on slippery surfaces without shifting gears.

The shaft is made of tubing 2.375 inches outside diameter and 1.531 inches inside diameter.

3. Front Pump Driven Gear—This gear is an essential part of the new transmission's hydraulic control system. It maintains correct oil circulation and pressure within the transmission.

The finished gear, measuring $4\frac{3}{16}$ inches o.d. and approximately $\frac{5}{8}$ inch on the i.d., has 36 gear teeth. The teeth are broached simultaneously on a vertical broacher.

All three parts are made from carbon steel seamless mechanical tubing which is cold drawn and finished to

Convertor reaction shafts, made from Pittsburgh Steel's seamless mechanical tubing, are assembled into transmission cases at this station in an automaker's huge plant. The shaft transmits torque to the gears.

exacting specifications. The automaker who chose Pittsburgh Steel's tubing for three transmission parts carefully spelled out his specs for fine grain structure, machinability and weldabiiity.

Those specifications were met by skilled tube mill men so that finished tubes were uniform—from length to length and from one shipment to another.

A measure of their skill is demonstrated by broaching which gives tubing grain structure a critical test. Rejects from peeling or chipping drop with Pittsburgh tubes.

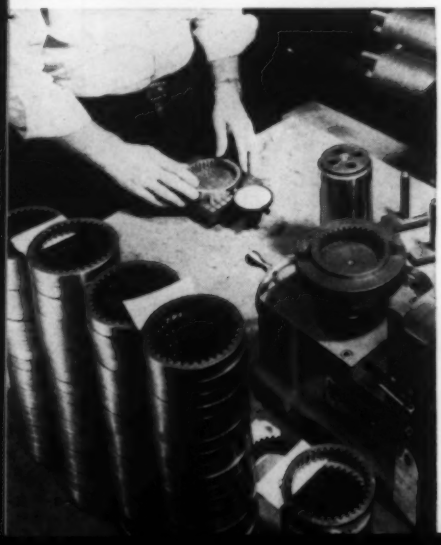
Machinability also is a severe test. In operations where tolerances are held to one-half of one thousandths of an inch, good machinability results in even, smooth production of parts which will pass sharp eyes of inspectors.

Welding operations carried on in automated lines can't be a haphazard operation or one in which quality of welds isn't uniform. Here again Pittsburgh Steel tubes keep production flowing smoothly and produce welds which hold up in field service.

Whether you're making automobile transmissions, hydraulic cylinders, axles or any other product requiring good tubing, you'll profit when you turn to Pittsburgh Steel. Skill of the men in the mill, modern equipment, engineering and metallurgical service available all combine to give you a satisfactory product—one backed by service and dependability.

Act today to get better tubes and service. Telephone or write the nearest district sales office listed below. You'll be glad you did.

Coming off an automated production line, these gears will be assembled into a front pump on a new type of auto transmission.



Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

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Grant Building • Pittsburgh 30, Pa.

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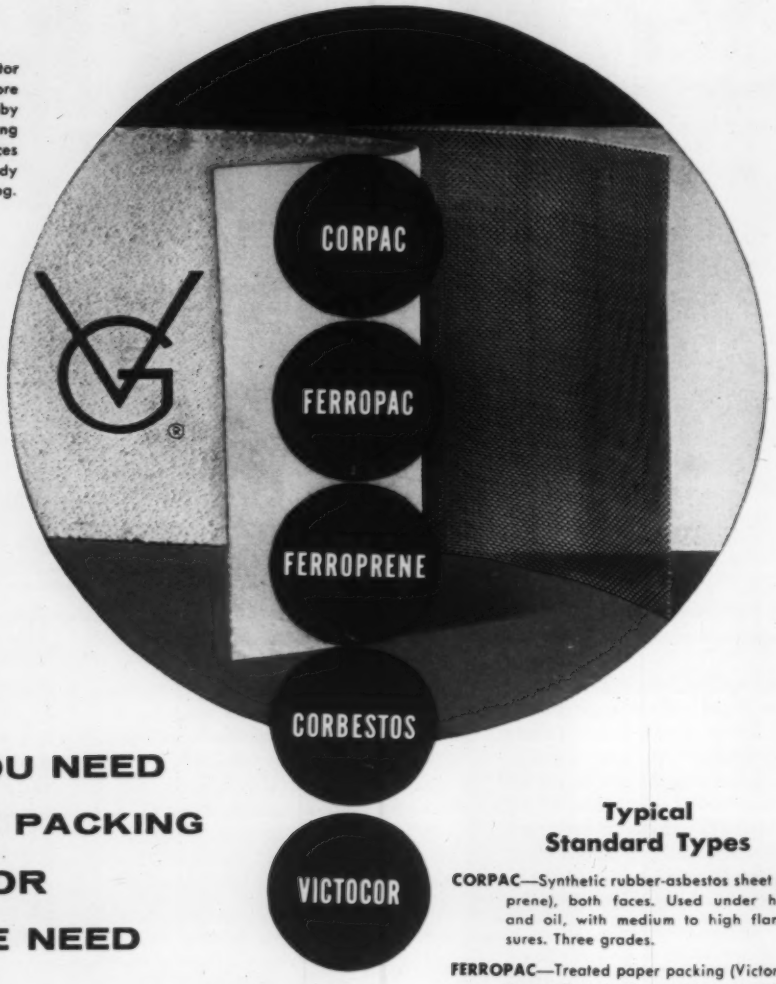
Atlanta, Chicago, Cleveland, Dallas, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

Circle 444 on Page 19

LOCKED-FOR-LIFE Victor construction. Packing and core are permanently bonded by means of formed tang projections on both faces of core, clinched into body of packing.



WHERE YOU NEED STEEL CORE PACKING VICTOR FILLS THE NEED

Where you're sealing under heavy loading, pounding or temperature, steel core packing is the modern specification. Its greater benefits and values are firmly established.

Actually it's the core that maintains a tight seal under tough conditions. It holds the packing in place, prevents shifting and extrusion. It resists torque loss on flattening because its effect on packing compressibility is nil.

From the widest range of highly engineered, SAE-ASTM rated packings, Victor literally can "tailor-make" steel core gaskets to your most precise specifications. Where needed, Victor successfully modifies the characteristics of standard types with virtually unlimited combinations and structures.

Get unbiased recommendations with complete technical and application data from your local Victor Field Engineer. Or contact the factory directly. Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

Typical Standard Types

CORPAC—Synthetic rubber-asbestos sheet (Asbestoprene), both faces. Used under high heat and oil, with medium to high flange pressures. Three grades.

FERROPAC—Treated paper packing (Victorite), both faces. For service against gasoline, oil, grease, water, under medium flange pressures. Holds up under frequent dismantling.

FERROPRENE—Compressed asbestos sheet packing (Victopac) one side, compounded synthetic rubber (Victoprene) on other. Useful under high heat and oil; low to medium flange pressures.

CORBESTOS—General-purpose, beater-treated asbestos sheet packing for use on oil, gasoline, water, steam, antifreeze. Adaptable to all temperature and bolting pressure needs. Six standard structures including double-sided, single-sided, steel-faced and laminated.

VICTOCOR—Compressed asbestos sheet packing, both faces. Low torque loss. High heat and crush resistance. For high flange pressures on hot oils, gasoline, water, antifreeze.

Your best sealing guide—Victor Gasket Engineering Catalog No. 505.

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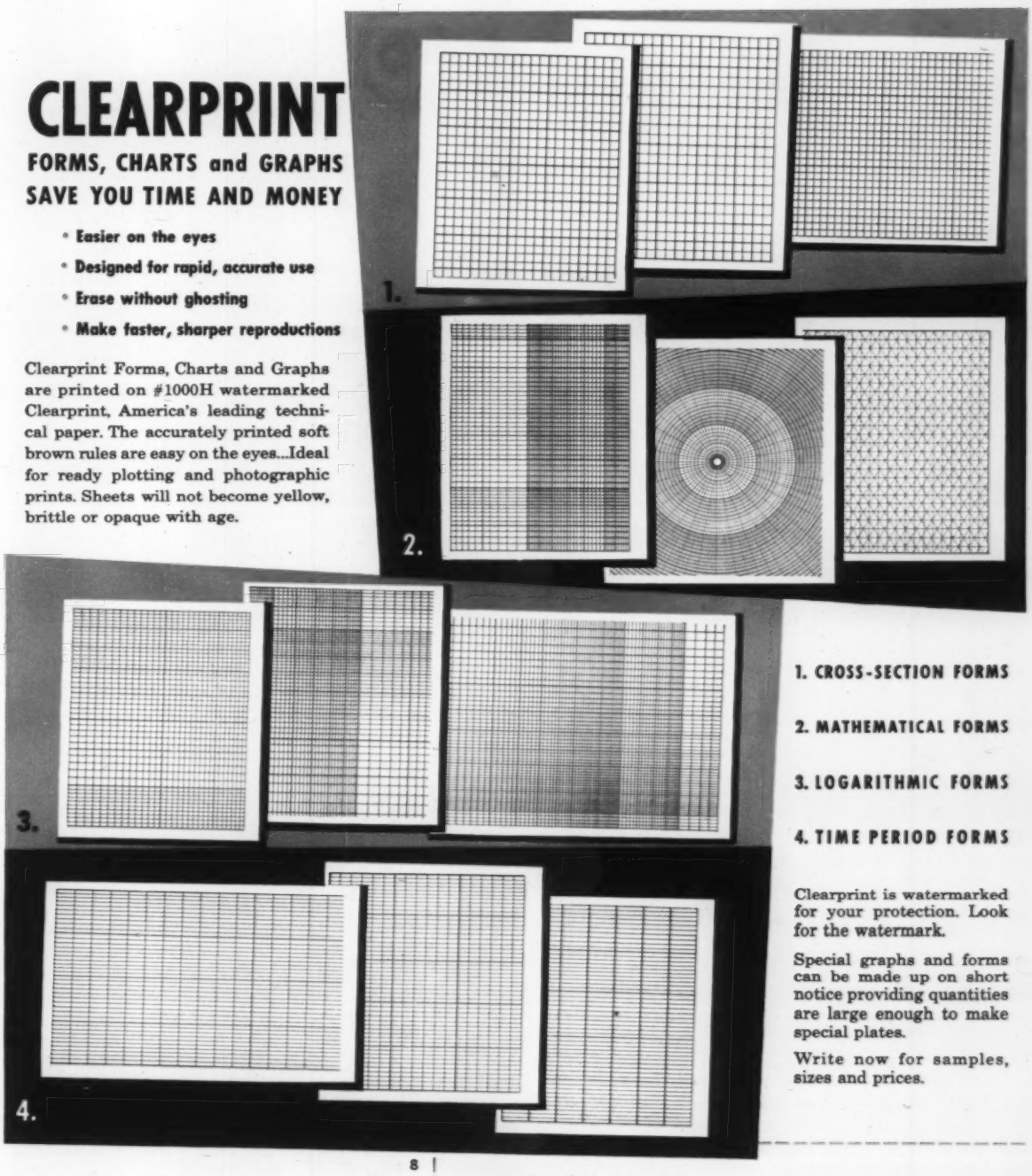

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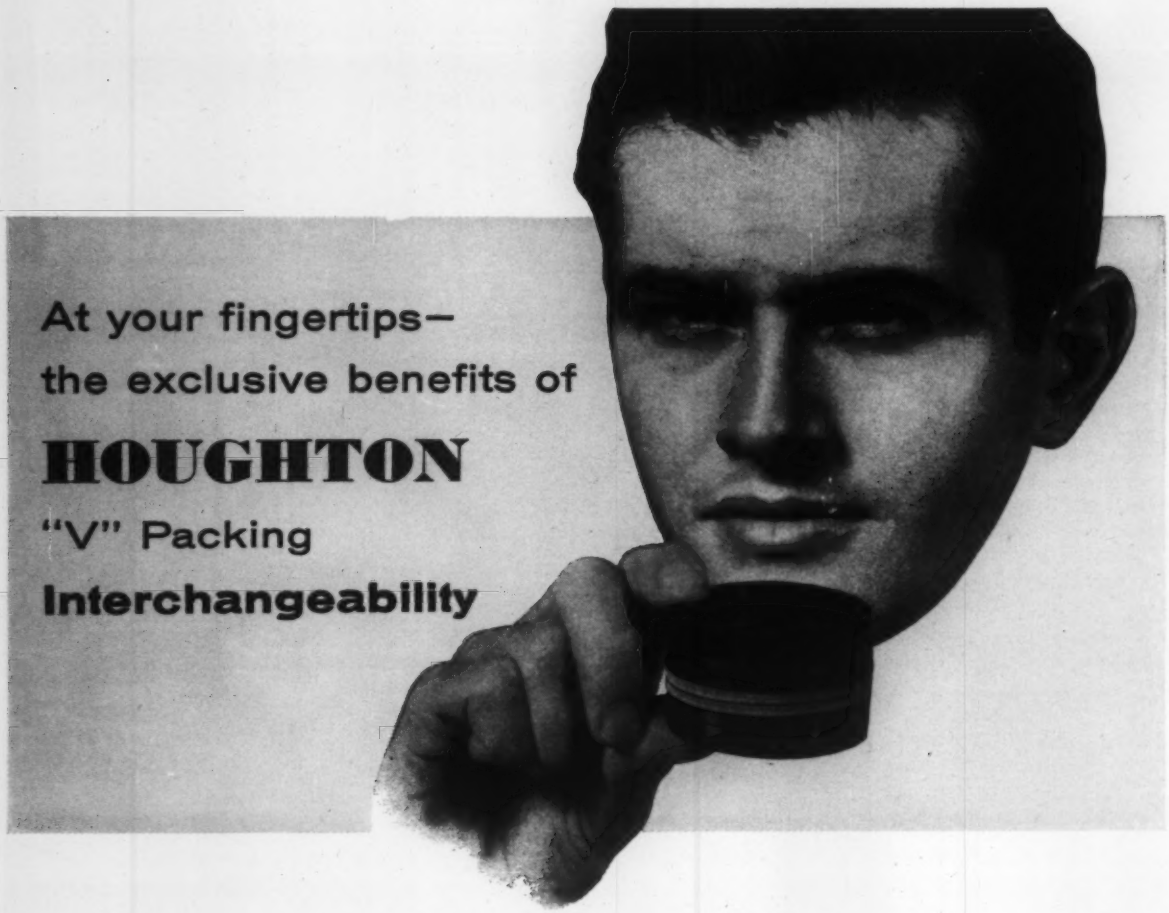

COMPLETE INTERCHANGEABILITY among Houghton leather, rubber, and fabric "V" packings provides users the solution to a long-standing problem—the choice of packings for an application that demands properties no single packing material can provide.

Now, the identical stack heights of all Houghton "V's" permit *unlimited* switching of "V" combinations in any gland, either with sets of the same material, or among units of different materials within a set.

You can use a leather "V" for anti-extrusion, strength, and low friction, with a rubber unit for wiping efficiency and low cost. You can switch from rubber to a fabricated unit to gain extra strength. You can even use all three "V's" in one set, all in the same gland.

Houghton interchangeability of packings is a terrific advantage to designers who specify gland size according to J. I. C. Standard Stack Heights. New efficiency, better sealing, better performance result because you can mix packings any way you wish—get the exact kind of seal you wish.

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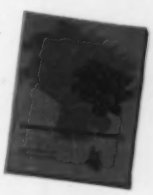
Circle 447 on Page 19

HAYNES Investment-Casting Solves the *tough* design problems

INTRICATE DESIGNS Mass-Produced Economically ...by Investment-Casting

Intricate shapes in hard-to-machine metals . . . sound metallurgical structures . . . close as-cast tolerances . . . smooth surfaces . . . are all available on a mass-production basis through HAYNES' investment-casting process. This modern mass-production method enables the design engineer to select the best alloy and most efficient design for an application. Desired parts can be made to specifications economically, regardless of how difficult or costly they might be to produce by other methods.

Haynes Stellite Company's extensive services and experience . . . complete tooling, production, quality control, metallurgical, and finishing facilities . . . plus a staff of more than 200 craftsmen . . . plus a selection of more than 25 alloys . . . guarantees that here you will obtain all the benefits the process has to offer.



For complete details, ask for our 40-page book. Write to HAYNES STELLITE COMPANY, Division of Union Carbide Corporation, Literature Section, 30-20 Thomson Ave., Long Island City, N.Y.

Inspecting Castings—Every casting is carefully inspected to insure top quality. "Zyglo," gamma ray, x-ray, and hundreds of precision gages are available to make sure parts meet specifications.

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A new dimension in flexibility!

You get *up to 70°* usable working angle (or equivalent shaft offset) with *two* Rzeppa Constant Velocity Universal Joints connected for double-action flexibility.

Rzeppa (pronounced "Sheppa") Joints, used singly or in combination, give 100% smooth torque with the strength and capacity required by heavy-duty coupling and drive-line applications. And every Constant Velocity Universal Joint is built for a long life of trouble-free service.

Call or write today for performance and engineering facts on the complete line of Rzeppa Constant Velocity Joints for every aircraft, marine, vehicular and industrial speed.

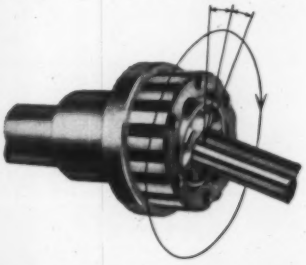
RZEPPA "SHEPPA" *Constant Velocity Universal Joints*

58RJ-1

THE GEAR GRINDING MACHINE CO., 3937 CHRISTOPHER, DETROIT 11, MICHIGAN • MANUFACTURERS OF: FULLY AUTOMATIC GEAR GRINDING MACHINES, DETROIT SCREWMATIC 750 SINGLE SPINDLE SCREW MACHINES

Plus RZEPPA'S smooth money-saving action

Old-fashioned pin or slipper-type joints speed up and slow down twice during one revolution, must use precision alignment techniques to compensate for "rock and roll" action at extreme angles.



Rzeppa Joints operate without chatter or bounce. Ball bearings deliver smooth rotation, reduce friction for longer joint and shaft life.

ACTUATE

MORE QUICKLY . . .
EFFICIENTLY . . .
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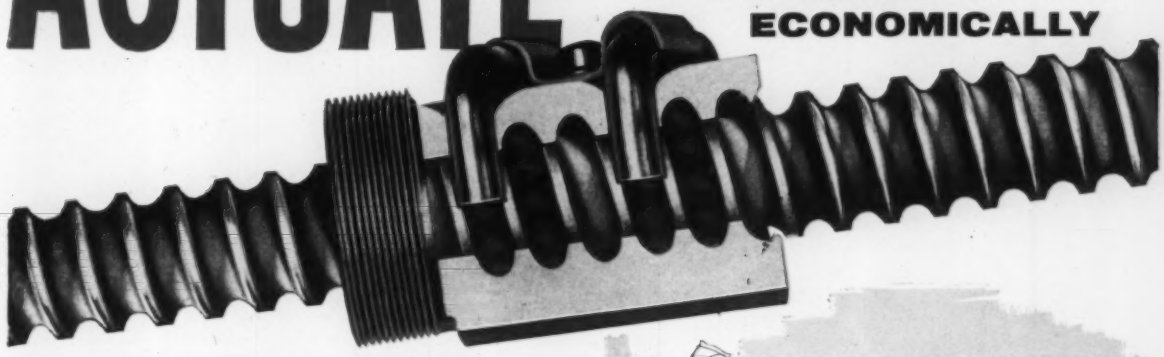


ROLLED THREAD
SAGINAW b/b SCREWS
Give Volume Products New Production and Sales Advantages

Because Saginaw employs an important anti-friction principle—steel balls recirculating in closed-circuit raceways—b/b Screws provide efficiencies of over 90%—perform up to *5 times* better than acme screws. Saginaw b/b Screws require far less torque—save up to 85% on operating power or manual effort. They are smaller and lighter than comparable units—permit smaller motors and gear boxes; often eliminate clumsy auxiliary parts. May be used with flange, trunnion, worm wheel or torque tube adaptors. Smooth, almost frictionless operation assures long, trouble-free performance, even in extreme temperatures and with lack of lubrication.

"OFF-THE-SHELF" STOCK REDUCES COST

Saginaw b/b Screws are the only kind stocked in seven commercial rolled thread sizes, in 6-inch increments of length (up to 4 ft. for .375" BCD, 8 ft. for .631" BCD, and 11 ft. for all larger sizes.) Ball Circle Diameters are as follows:

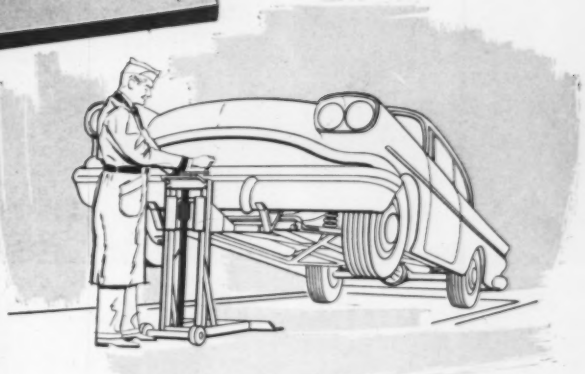
.375" .631" 1.000" 1.171" 1.500" 2.250" 3.000"

MANY TYPICAL APPLICATIONS

Saginaw b/b Screw standard assemblies have been successfully applied to such products as bumper jacks, automatic garage doors, automobile seat adjusters and window lifts, beauty parlor chairs, hospital beds, and circuit breakers. They are also being used in heavy industrial equipment like die table positioners, drill presses, lift trucks and welding machines.

FREE ENGINEERING HELP FOR YOUR SPECIAL APPLICATION

Let Saginaw's experienced engineers help you solve your special application problems. Just write or phone us your requirements, or fill in and mail the handy coupon below.

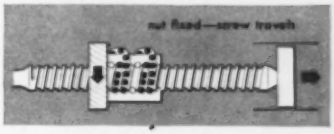


With a Saginaw b/b Rolled Thread Screw in the jack, just a spin of the handle raises a heavy car easily . . . smoothly . . . safely.

HOW THE WORLD'S MOST EFFICIENT ROTO-LINEAR DEVICE WORKS

NUT TRAVELS: When rotary motion is applied to the screw, the b/b nut glides along the axis of the screw on rolling steel balls, converting rotary force and motion to linear force and motion with 4/5 less torque.

SCREW TRAVELS: When rotary motion is applied to the b/b nut, the screw glides along its longitudinal axis on rolling steel balls, converting rotary force and motion to linear force and motion with new efficiency.



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b/b Screw and Spline Operation
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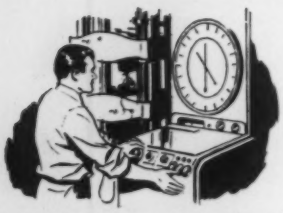
Saginaw
ROLLED THREAD ball bearing Screw

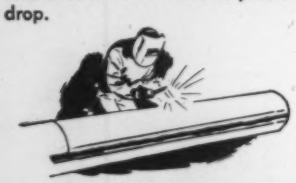
SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

Premium quality extruded steel pressure tubing at standard prices



Transverse Strength, 30% to 50% higher than conventional, withstands higher internal pressures.

Improved Internal Finish offers less resistance to flow — reduces pressure drop.



Fewer and Faster Field Welds, due to close concentricity and uniform wall thickness. 50-foot lengths require fewer joints, reduce welding costs 50-60%.

High performance Chrome-Moly Alloy extruded steel pressure tubing *...in diameters from 14" to 18" o.d....in standard wall thicknesses ...in lengths from 20 to 46 feet...* is now available *from stock* for immediate delivery at standard prices.

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The unusual properties of this extruded tubing, such as exceptionally high transverse strength, impact strength and ductility, make it ideally suited to high-temperature, high pressure applications in the power, petrochemical, food processing and other process industries.

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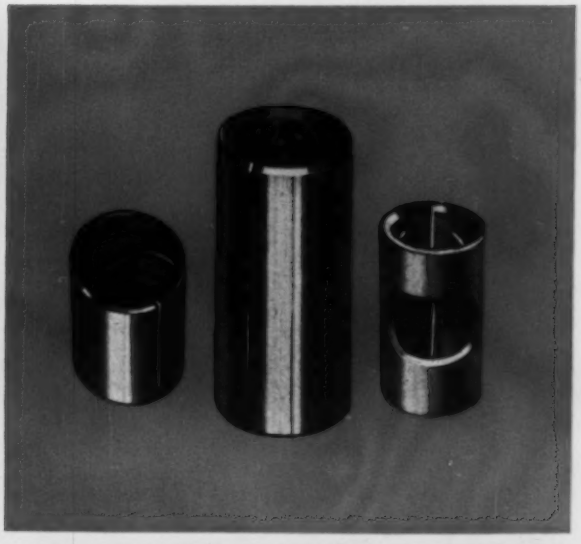
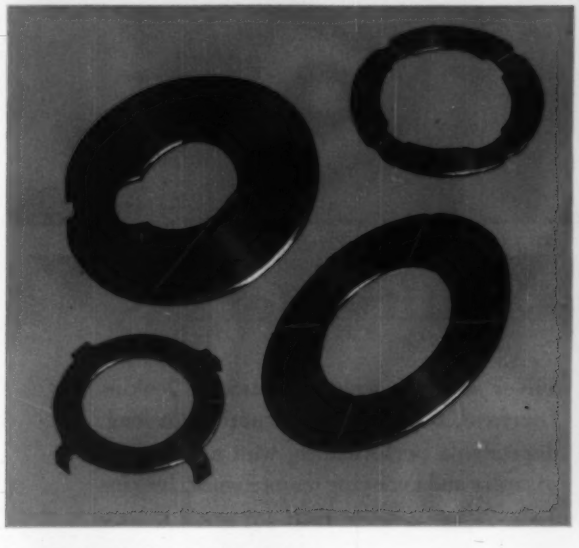
These alloy linings meet 95% of engine bearing needs

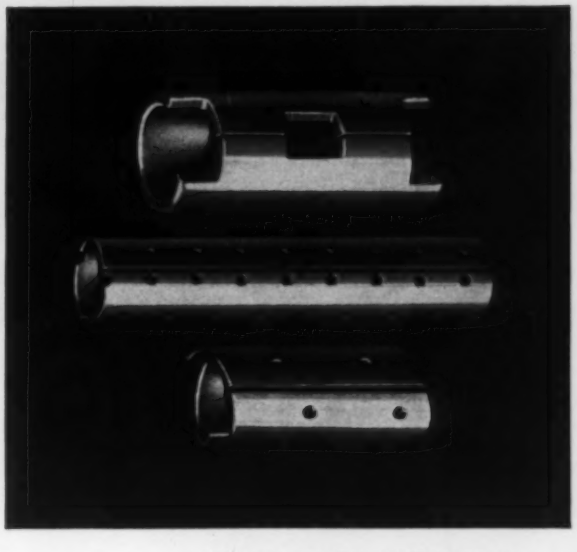
Experience shows a steel back, lined with tin- or lead-base babbitt, medium- or heavy-duty copper-alloy or extra heavy-duty aluminum alloy, meets most performance requirements.

Bimetal and Plain Bushings offer substantial economies

Rolled split plain bronze, steel or aluminum; or steel lined with bronze, babbitt or copper-alloy. Many design variations possible, plus volume production economies.







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Cold rolled for heavy duty. Steel faced with copper-alloy on one or *both* faces. Nibs, lugs, coined oil grooves. Flat, spherical or special shapes. From 1″ to 6″ O.D.

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Economical Spacer Tubes for Hundreds of Applications

Money-saving substitute for iron pipe, tubing or machined parts. Delivered ready for assembly, to exact dimensions—or can be brazed to other components.

FEDERAL-MOGUL DIVISION

FEDERAL-MOGUL-BOWER BEARINGS, INC., 11045 SHOEMAKER, DETROIT 13, MICHIGAN

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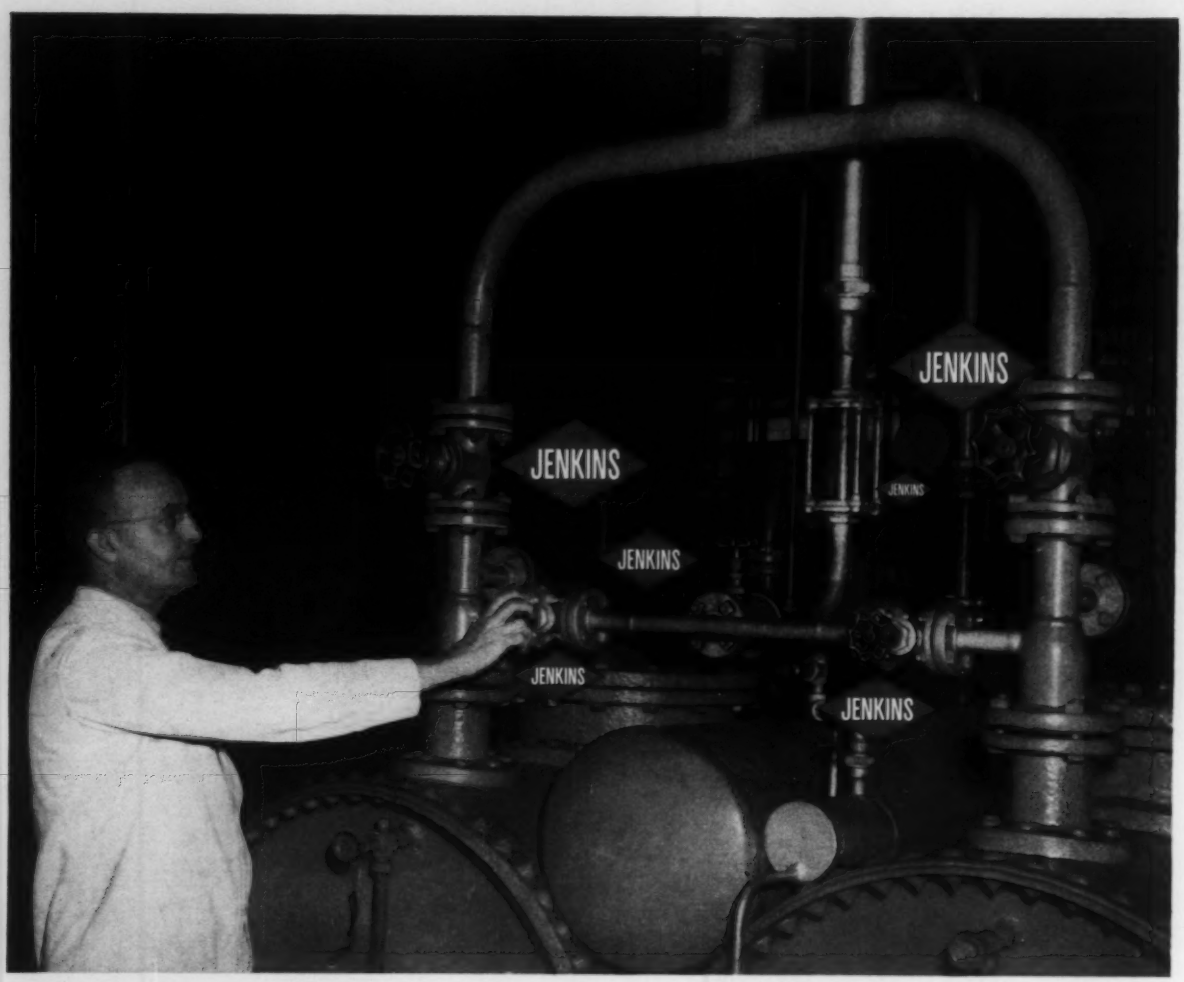

No Stinting on Quality Here

For equipment you design, provide valves that say: *No stinting on quality here.* Provide valves which all your customers associate with top quality . . . the same valves many insist on for their plant piping . . . the valves marked with the famous Jenkins *Diamond*. Despite their reputation for long, dependable performance, with a minimum of costly and annoying maintenance, Jenkins Valves *cost no more* than any good valves.

Write us for information about the types of valves you require. Jenkins Bros., 100 Park Ave., New York 17.

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JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
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SINCE 1864
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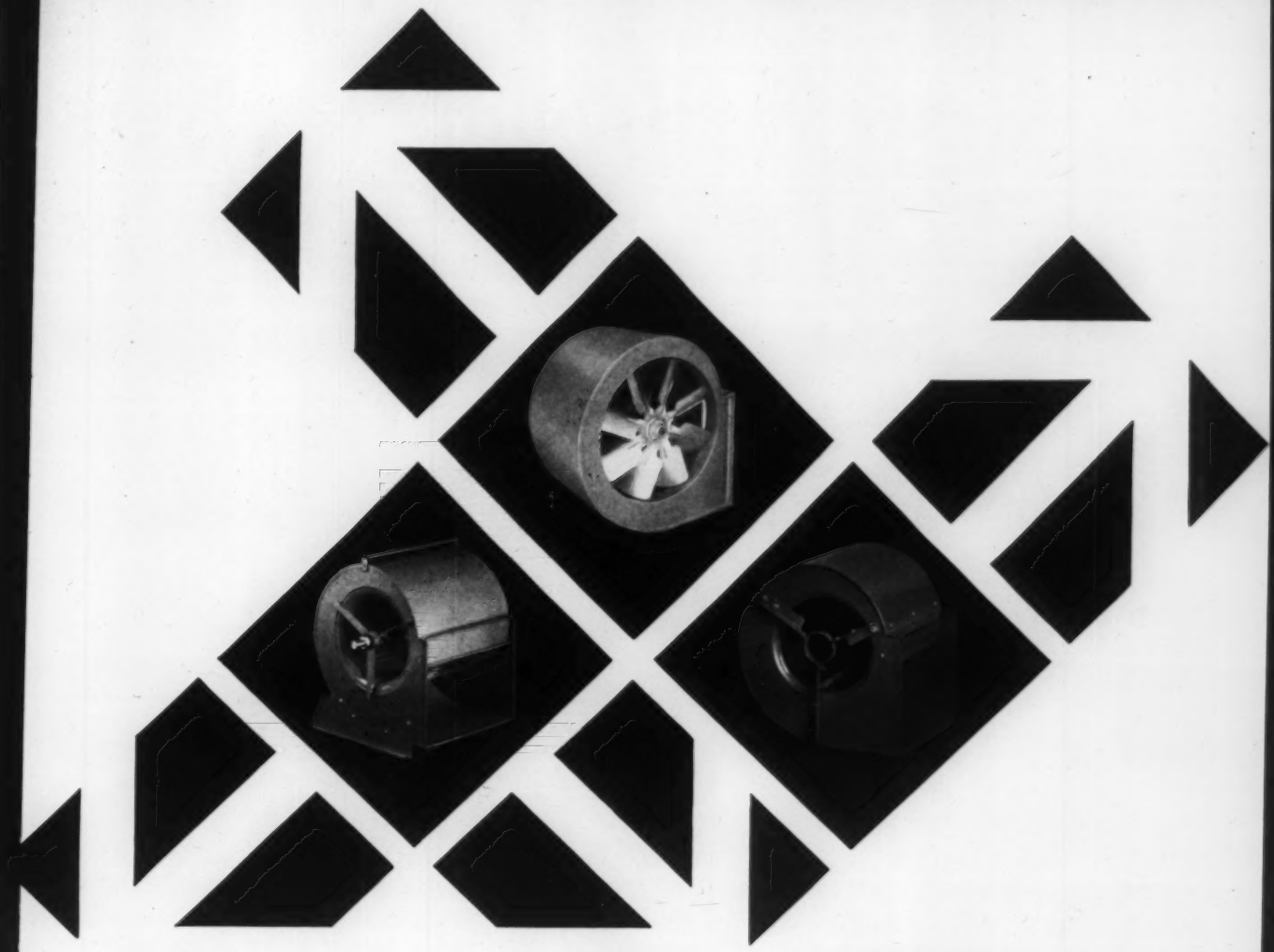


FULL COVERAGE

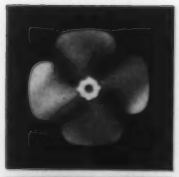
No matter which way the wind blows with your blower unit requirements—belt-driven, direct drive or radial-axial mixed flow—Torrington has the solution to your problems.

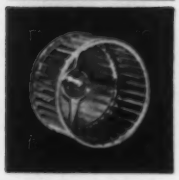
This means complete technical data and the proved-out performance rating on three lines of basic blower unit designs.

In addition to the standard direct drive units and the already famous VariBasic belt driven series, latest and most spectacular addition is the exclusive Radiax unit, combining the optimum performance characteristics of both radial and axial flow techniques.

The result is FULL COVERAGE—the best "problem insurance" you could have.

Talk to Torrington!





THE TORRINGTON MANUFACTURING COMPANY

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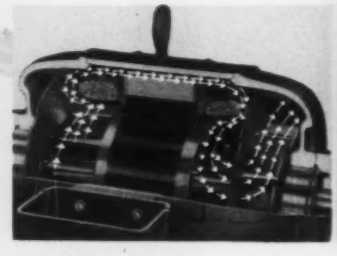

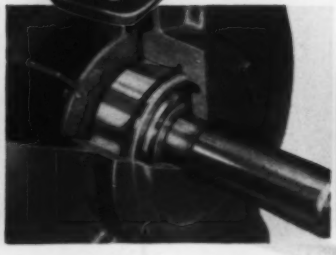

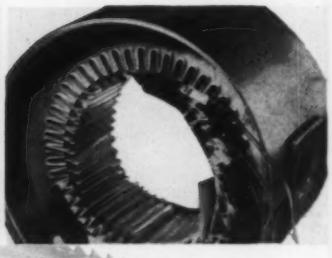

Highly efficient dual-sweep ventilation

Tandem fans, one pushing and one pulling, cool motor from end to end . . . air-wash field coil ends . . . eliminate "hot spots" . . . greatly prolong motor life!

Fully sealed prelubricated bearings

Run in double-width races . . . have extra-large lubricant reservoirs . . . seldom need re-lubrication . . . are quickly, easily inspected by removing cover plates!

Life-prolonging *Mylar insulation

Has excellent dielectric qualities . . . resists tearing and aging . . . assures virtually permanent protection. Rag paper backing cushions against abrasions and punctures!

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MOTOR STAMINA

DoALL *machines saw their way to success!*

DoALL Contour-matic Band Machine

The DoALL Company equips its versatile Power Saws and Contour-matic Band Machines with sturdy, dependable R&M motors. These motors are precision-built, with ample reserve power that helps DoALL achieve record-breaking cutting rates while working at greater feed and speed pressures.

In thousands of DoALL-equipped plants, R&M motor stamina has proven itself. R&M motors take toughest DoALL jobs in stride—powering their new Demon high-speed steel cutting tool in the machining of harder-to-cut tough new alloys. DoALL versatility depends on reliable power to saw, file, grind or polish all materials. The same strong R&M motor also drives the machine's hydraulic and air pumps, providing smooth power for automatic stock feeding, work table positioning, etc.

If your product requires heavy duty motors designed for faster, more versatile production, plus top dependability, Robbins & Myers can help you.

Contact your R&M representative or write today for Bulletin 520-MD

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

R&M builds motors from 1/200 to 200 horsepower

Circle 455 on Page 19

Another Tinnerman Original...

Self-retaining "U" and "J" SPEED NUTS® cut assembly costs up to 50% or more!

If you are worried about rising assembly costs, let one-piece "U" and "J" SPEED NUTS keep costs down . . . and improve your product.

They can't fall off, once they've been pressed into screw-receiving position. No welding, staking or other secondary fastening devices needed. You eliminate lock washers – spring steel SPEED NUTS are self-locking, make vibration-proof attachments.

SPEED NUTS are ideal for blind assembly or hard-to-reach locations. Apply them *before* you paint panels without danger of paint-clogging. Or *after* porcelainizing, without damage to finishes. The "U" type is similar to the "J" type, shown above, but is used where full bearing surface on the lower leg is required.

A free Fastening Analysis can tell where SPEED NUT brand fasteners belong on your products. Call your Tinnerman representative —he's listed in most major telephone directories. Or write to:

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Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

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Speed Nuts®

FASTEST THING IN FASTENINGS®

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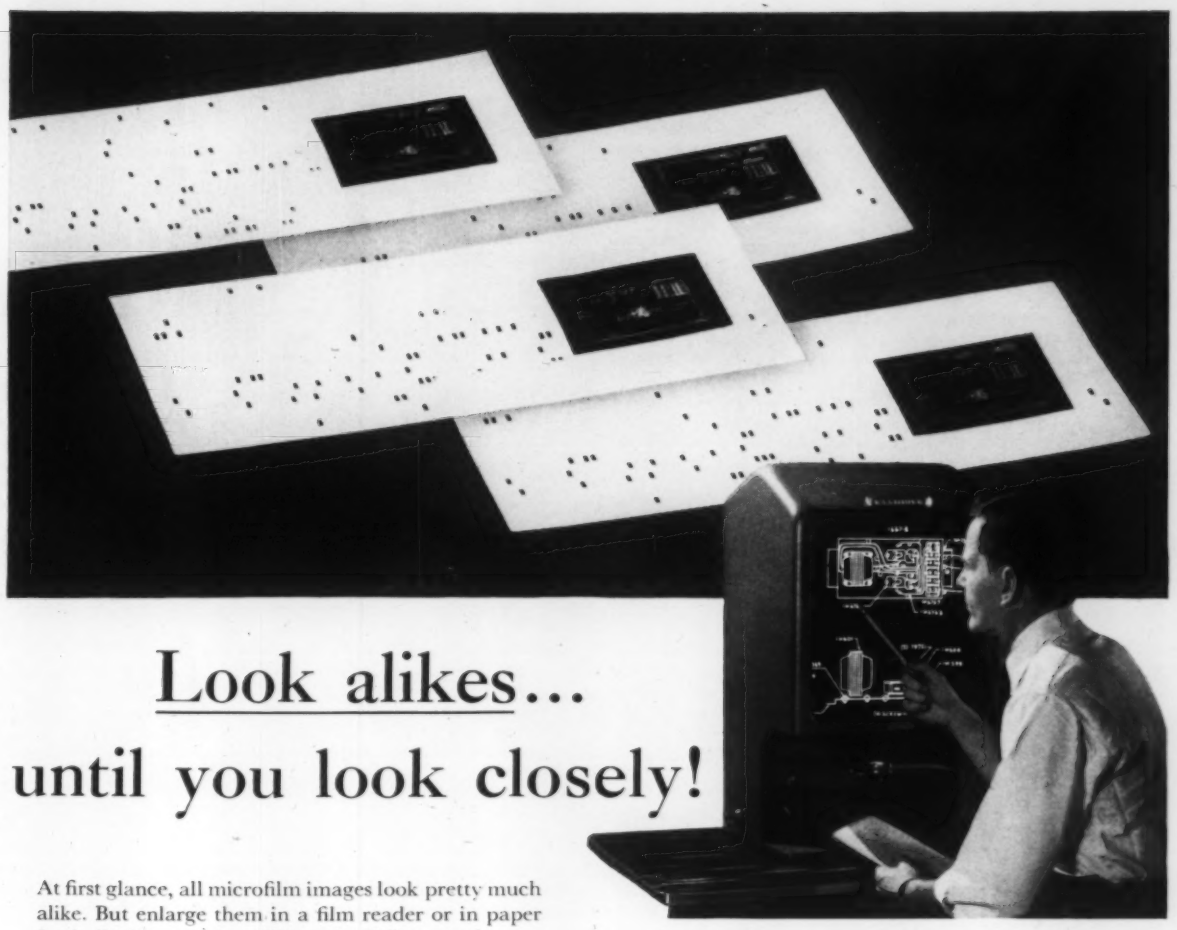

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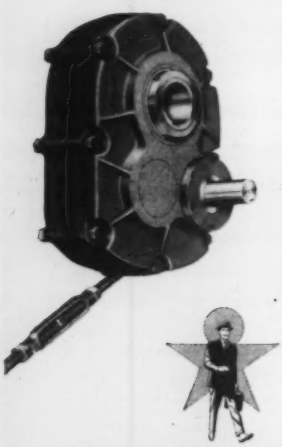
...AMERICA'S MOST WIDELY USED SHAFT-MOUNTED SPEED REDUCER



Extreme ruggedness and top quality are built into every detail of the Dodge Torque-Arm Speed Reducer—from the specially heat treated helical steel gears to the corrosion resistant semisteel housing. Broad demand has made it necessary to add sizes until today Torque-Arm is America's most complete (and most widely used) line of shaft-mounted speed reducers. Capacities range from 1 to 100 hp; output speeds from 12 to 378 rpm.

Torque-Arm is mounted on the driven shaft, in any vertical or horizontal position. It is anchored by the torque-arm fastened to any fixed object. No need for foundation, flexible coupling, sliding base. No lining up difficulties. The unit is driven through any V-belt drive. Savings up to 1/3 are possible and Torque-Arm's efficiency is high. It delivers 97% efficiency in double reduction models; and almost 99% in single!

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3300 Union Street, Mishawaka, Indiana

CALL THE TRANSMISSIONEER
—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the white pages of your telephone directory for "Dodge Transmissioneer."

DODGE
of Mishawaka, Ind.

Now improve design five ways

1. Save Space
2. Reduce Weight
3. Save Materials
4. Speed Assembly
5. Reduce Production Operations

NATIONAL RETAINING RINGS are the economical, simple method of locating and positioning machined parts or bearings on shafts, pins or in housings. Each application results in substantial cost reductions as machining or grinding shaft stock to form shoulders is eliminated. National Rings simplify product design, save space and weight. Rings are available in a wide range of finishes to meet specific requirements.

ASK A NATIONAL ENGINEER for assistance on your specific retaining ring application—his experience includes service-proven applications on instruments, tools, engines, heavy machinery, toys... thousands of products of metal, plastics and wood. Ask for complete information on cost-reducing National Retaining Rings.

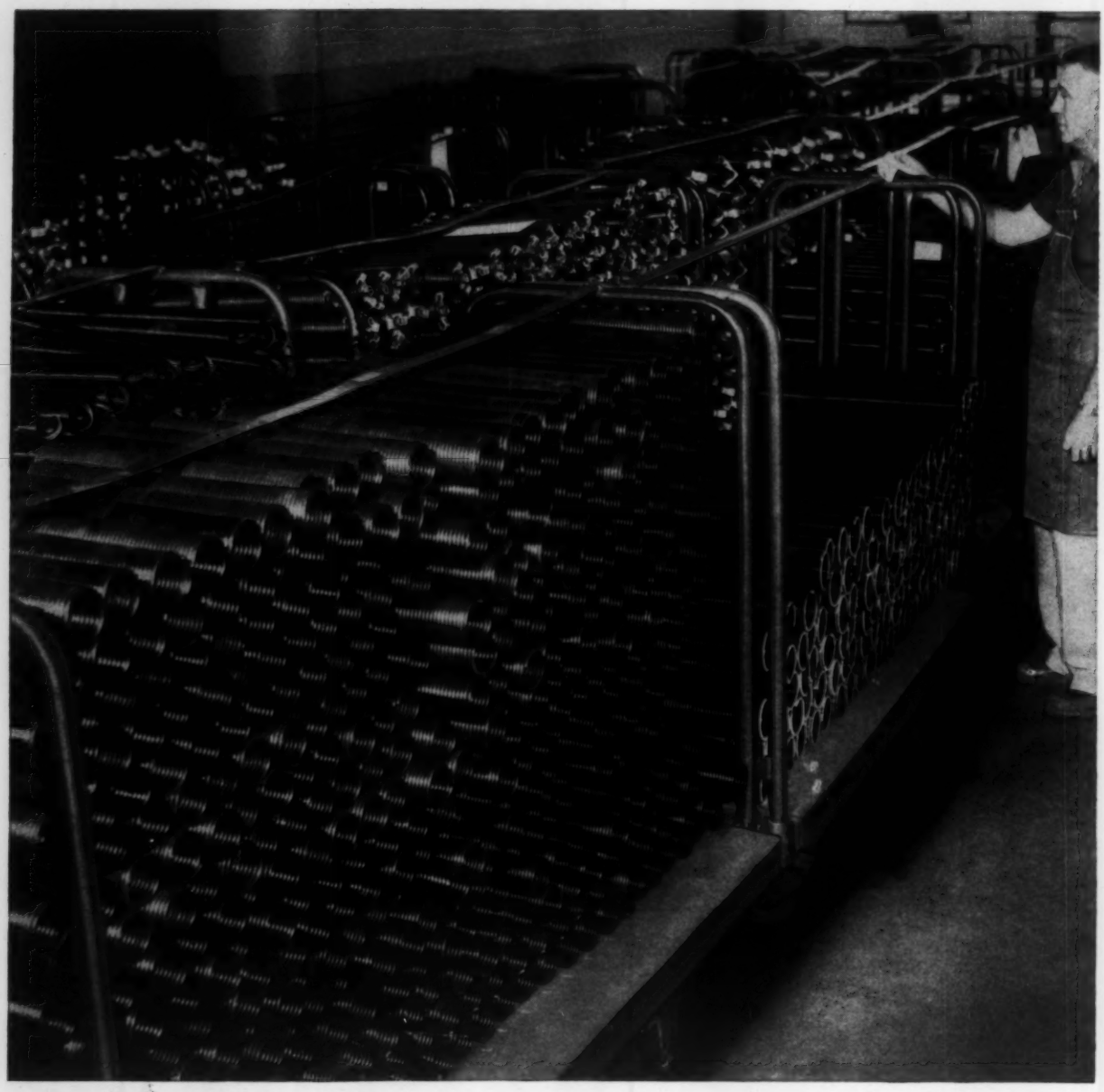
Standard rings available in round, square and rectangular types in carbon spring steel. Bronze beryllium copper, stainless steel, aluminum and special types custom designed to your exacting specifications.

THE NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN, U.S.A.

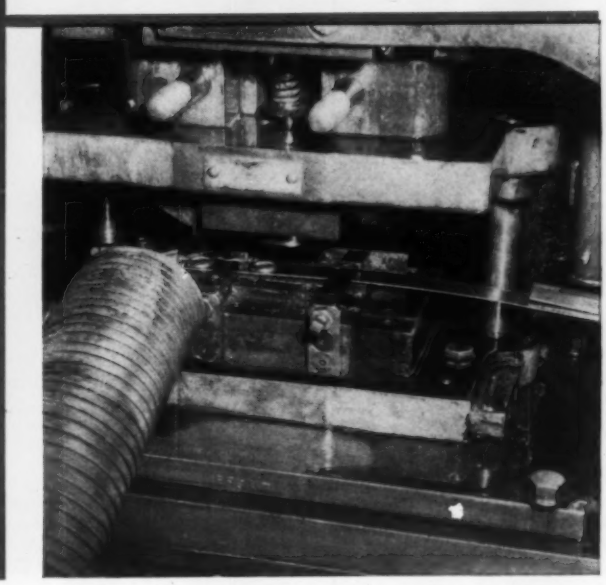
How Frantz Manufacturing Co. improves with these USS products: Amerstrip,



Springs with stamina. These long-lasting American Quality Springs will go into garage doors and other Frantz building specialties. American Quality Springs are available in all sizes, shapes, and descriptions. They are inspected through every stage of the manufacture and meet the highest standards of quality.

roller skates and garage doors

Amerled, and American Quality Springs



AMERSTRIP IS USED in the manufacture of almost every part of the 15 types of Hustler Corporation skates made by Frantz. These skates will stand up under the punishing wear children may give them —yet maintain their attractive finish. Amerstrip is tailored to each particular job . . . has the physical properties to assure a good performance and efficient manufacture.

Tough, durable American Quality Springs play a major part in the smooth operation of Frantz garage doors. These quality springs make garage doors lower in cost and easier to operate than doors using counterweights—and they have proven equally durable.

Amerled ups machining speed 17.4%

Frantz has been machining its own axles and bearing cones for roller skates and conveyor wheels. Recently they switched to Grade "A" free-machining USS Amerled. This easy-to-machine, lead-bearing steel meets all their requirements at lower cost as it permits them to increase machining speed from 320 to 375 S.F.M.—a 17.4% jump—with no loss in tool life . . . and less rejects.

American Steel & Wire produces a complete line of manufacturers wire products. Our large technical staff can tailor these items to fit your individual needs. Call our nearest Sales Office today. American Steel & Wire, General Offices, Rockefeller Building, Cleveland 13, Ohio.

Precision. In the top picture, wheels are being added to roller skates at Frantz's final assemble table. In the bottom picture, a Bliss Roll Feed Punch Press is stamping ball races from 1⅜" .047 USS Amerstrip at the rate of 195 per minute. Frantz also makes heels, toes, and channels from Amerstrip.

USS, American, Amerstrip and Amerled are registered trademarks

American Steel & Wire
Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

Eastman

HIGH PRESSURE ASSEMBLIES

for

Responsive POWER

INSTANT response means extra POWER. Improving the "Power-Performance Ratio" of your equipment may mean an extra bucket per minute, extra tons per hour, extra loads per day.

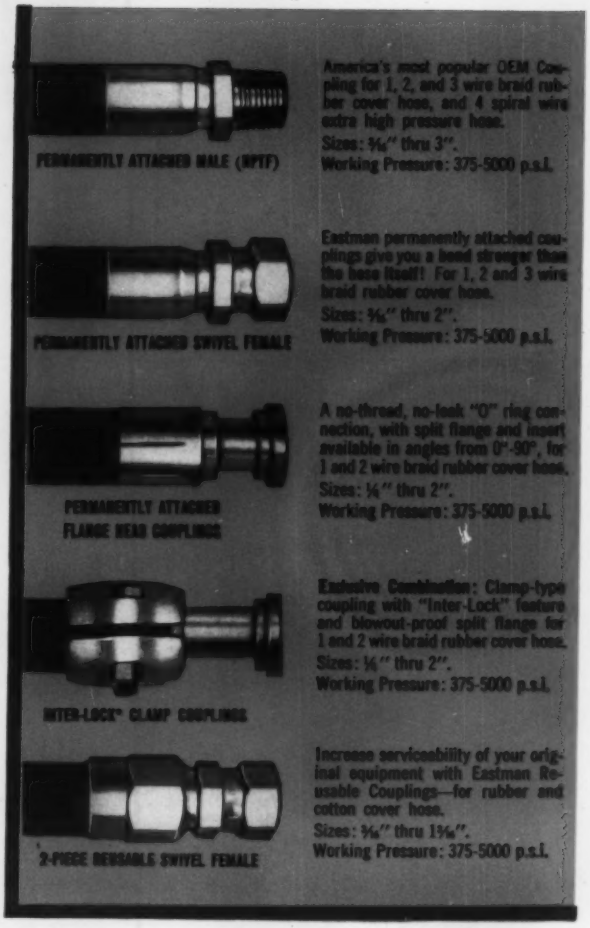
With the increasing emphasis on POWER, it pays to safeguard the most important link in your hydraulic system with Eastman *High Pressure* Hose and Tube Assemblies.

Eastman Coupling Design gives you maximum orifice, consistent with essential safety and strength, to provide "trigger-response" through unrestricted flow from pump to point of work—plus prompt return.

BENT TUBING TO YOUR SPECIFICATIONS

Eastman's modern, hydraulically-controlled tube bending equipment provides bent tubing to your precise specifications—made with flared or beaded ends for your required fittings. Quality workmanship assures satisfactory performance. Mass production economies assure competitive quotations.

For positive power delivery and efficiency throughout your hydraulic system—plus appearance and sales appeal—it pays to specify Eastman High Pressure Hose and Tube Assemblies for your original equipment.


PERMANENTLY ATTACHED MALE (NPTF)
America's most popular OEM Coupling for 1, 2, and 3 wire braid rubber cover hose, and 4 spiral wire extra high pressure hose.
Sizes: 3/16" thru 3".
Working Pressure: 375-5000 p.s.i.
PERMANENTLY ATTACHED SWIVEL FEMALE
Eastman permanently attached couplings give you a bond stronger than the hose itself! For 1, 2 and 3 wire braid rubber cover hose.
Sizes: 3/16" thru 2".
Working Pressure: 375-5000 p.s.i.
PERMANENTLY ATTACHED FLANGE HEAD COUPLINGS
A no-thread, no-leak "O" ring connection, with split flange and insert available in angles from 0°-90°, for 1 and 2 wire braid rubber cover hose.
Sizes: 1/4" thru 2".
Working Pressure: 375-5000 p.s.i.
INTER-LOCK® CLAMP COUPLINGS
Exclusive Combination: Clamp-type coupling with "Inter-Lock" feature and blowout-proof split flange for 1 and 2 wire braid rubber cover hose.
Sizes: 1/4" thru 2".
Working Pressure: 375-5000 p.s.i.
2-PIECE REUSABLE SWIVEL FEMALE
Increase serviceability of your original equipment with Eastman Reusable Couplings—for rubber and cotton cover hose.
Sizes: 3/16" thru 1 3/16".
Working Pressure: 375-5000 p.s.i.

Eastman
first in the field

MANUFACTURING COMPANY
Dept. MD-4 • MANITOWOC, WISCONSIN

WRITE FOR HIGH PRESSURE CATALOG!

Get on our mailing list to receive out latest Technical Bulletins, Catalogs and Special Inserts.

Circle 461 on Page 19

Circle 462 on Page 19→

One of Claymont's multi-torch automatic flame-cutters.

by d'Arazien

Main feature of the Claymont story is integration. For instance, consider one phase of our operation—the new Fabrication Shop. First, steel from Claymont's own open hearth is formed into plate on Claymont's own rolling mills and sent to the Fabrication Shop. Here, modern equipment welds, shears, presses, rolls, cuts or machines the plate to produce fabricated products for many industries.

CLAYMONT
FABRICATED STEEL PRODUCTS

CF&I

CHECK CLAYMONT FOR—Alloy Steel Plates · Carbon Steel Plates · Stainless-Clad Steel Plates · High Strength Low Alloy Steel Plates · CF&I Lectro-Clad Nickel Plated Steel Plates · Pressed and Spun Steel Heads · Manhole Fittings and Covers · Fabricated Steel Products · Large Diameter Welded Steel Pipe

PRODUCTS OF WICKWIRE SPENCER STEEL DIVISION · THE COLORADO FUEL AND IRON CORPORATION

Plant at Claymont, Delaware · Sales Offices in all Key Cities

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Get *SuperMarket* hydraulic service at your DENISON branch office

1. BRING US YOUR PROBLEM...

whatever hydraulic problem has you stumped. A trained Denison Hydraulic Specialist is ready to sit down with you and analyze your problem.

2. WE'LL DEVELOP YOUR CIRCUIT...

the most efficient hydraulic circuit to handle your specific needs. We can do this while you wait.

3. PICK OUT WHAT YOU NEED...

right off the shelf — from Denison's complete stock of hydraulic pumps, motors, valves and controls to 5000 psi.

4. TAKE HOME YOUR COMPLETE HYDRAULIC SYSTEM...

ready to go to work for you! Complete hydraulic circuit drawings and hydraulic parts are "under your arm" in a *complete package.*

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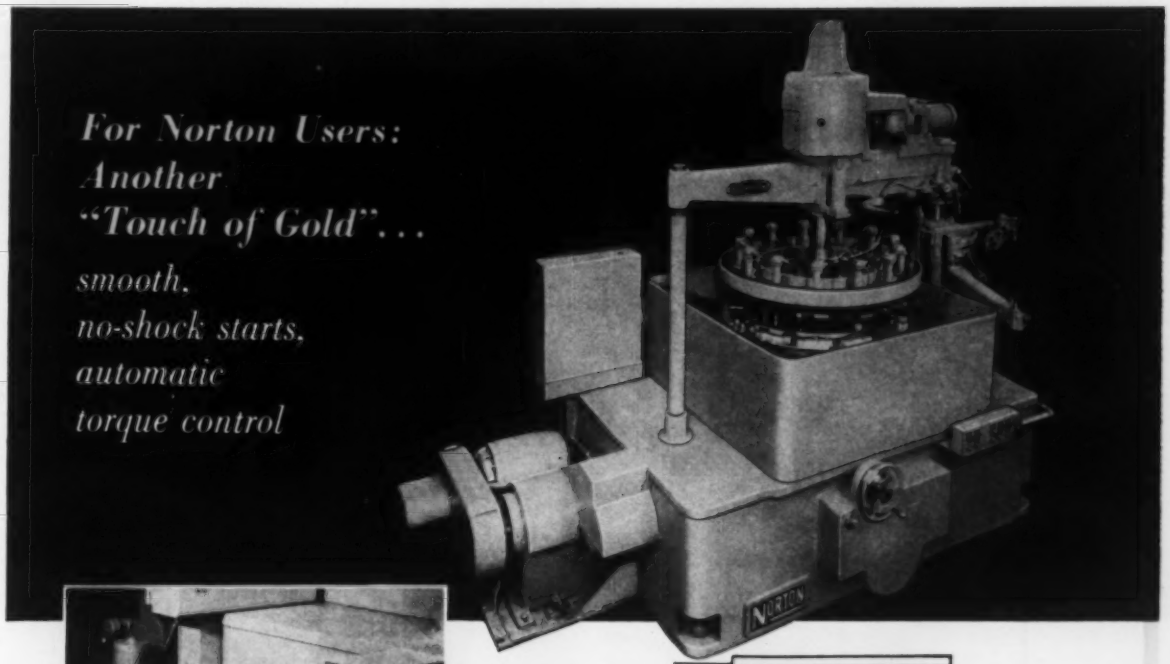
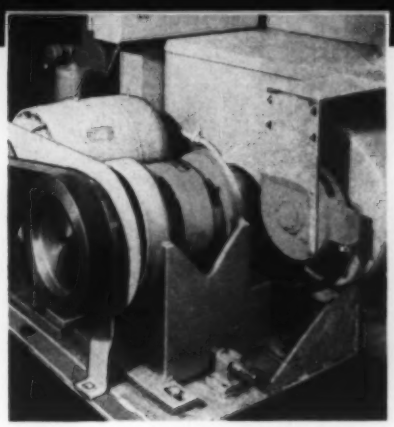
Circle 463 on Page 19

For Norton Users:
Another
"Touch of Gold"...
smooth,
no-shock starts,
automatic
torque control





with the VICKERS®

MAGNECLUTCH®

magnetic particle clutch and

MAGNEBRAKE®

An important component of Norton Company's No. 48-F Hyprolap lapping machine shown above is the Vickers Magneclutch. This outstanding clutch provides the smooth, no-shock starts and the reliable automatic torque control needed for precise metal finishing. The Vickers Magnebrake used on the Hyprolap machine insures smooth, reliable braking. Magnebrakes can also provide shockless, controlled deceleration.

If critical torque transmission is needed in your equipment, you'll find many advantages in the Vickers Magneclutch . . . a magnetic particle clutch that provides smooth operation with no grab or chatter, fast response and long life (there's no wear on torque transmitting surfaces). Write today for Bulletin 6000-A.

ELECTRIC PRODUCTS DIVISION — VICKERS

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ELECTRIC PRODUCTS DIVISION
1881 LOCUST STREET • SAINT LOUIS 3, MISSOURI

Circle 464 on Page 19

ALL NEW!

Veeder-Root Panel-Mounted High Speed Electrical Counters

...with electric resetting in 1/10th of a second

These new Series 1591 Electrical Counters fill the gap between standard and electronic counters for industrial, data processing, or laboratory and scientific uses. They're designed for accuracy and long life at very high speeds (rated at 3000 counts per minute, with extended test-runs up to 6000 cpm).

And they have the unmatched convenience of *instant push-button resetting*, either mechanically right on the machine . . . or electrically from a distance. Panel-groups of these counters can be placed right in your office . . . *and one button can reset an entire panel.* Counters feature large figures, small size, low-wattage coils for continuous duty and other V-R vantage points on which patents are pending.

These new and different counters are the latest evidence that Veeder-Root design and development always keep pace with modern counting requirements. Write for specifications and prices.

Added Evidence that Everyone Can Count on

VEEDER-ROOT
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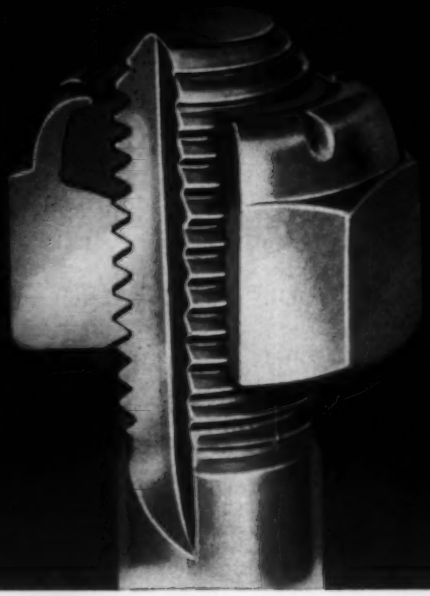
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

The nylon collared Elastic Stop nut never damages bolt threads!



The nylon locking insert ○* will not seize threads, gall or remove plating

The red nylon locking collar is an integral part of an Elastic Stop nut. Undersize in diameter in relation to standard bolt tolerances, this insert grips the entering bolt threads with strong, smooth nylon fingers that dampen impact loads and resist turning under the most severe conditions of vibration or shock. The perfect fit between bolt threads and the locking collar also serves to seal off internal bolt and nut threads and to protect them against corrosion. Furthermore the nylon insert is impervious to gasolines, oils, salt atmospheres, cleaning compounds and common acids. The remarkable wear resistance of nylon plus its elastic recovery makes Elastic Stop nuts reusable through more than a hundred on and off cycles.

Because an Elastic Stop nut is a one-piece unit it is less expensive to install than castellated nuts and cotter pins, or double nuts. Equally important, it is a *stop* nut that *locks at any position on the bolt* without requiring secondary "safety" devices; it is simple to adjust precisely—it is easily wrenched off or readjusted. Elastic Stop nuts have been used by American industry since 1930 to solve the toughest applications on railroad, automotive, earth moving and farm equipment, as well as on all types of electrical machinery.

Elastic Stop nuts are available in sizes ranging from a watchmaker's 0-80 through 3", and in many standard finishes and materials including carbon and stainless steels, brass, duronze and aluminum.

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA

also maker of the ROLLPIN TRADEMARK

*The Red Locking Collar is a Registered Trademark of ESNA

Elastic Stop Nut Corporation of America
Dept. N27-44, 2330 Vauxhall Road, Union, N. J.

Please send me the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Company_____

Street_____

City_____ Zone____ State_____

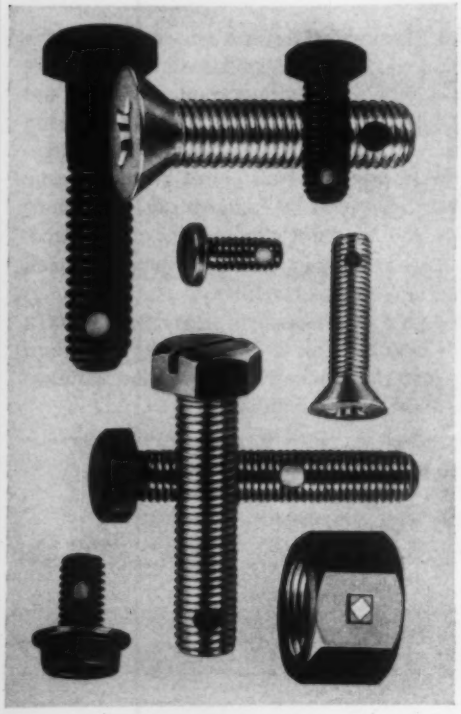
"We've built a better mouse trap with REPUBLIC ELECTRO PAINTLOK SHEETS"

"If we expected the world to beat a path to our door," continues Mr. Coughanor, "we knew every detail of design and material in the Self Sett Trap had to be exactly right. As a result, extensive tests have been conducted which prove design efficiency. And experience has proved Republic Electro Paintlok is the best steel sheet we can buy for economy, long life, and excellent paint-holding qualities. The combination of these factors gives us the best, safest, most foolproof product on the market."

This enthusiasm for Republic Electro Paintlok® is echoed by many other product manufacturers faced with a wide range of forming and application problems. The reason is the chemically treated zinc surface of Republic Electro Paintlok which leaves the mill in prime condition for painting, and won't crack, flake, or peel under any forming operation permitted by the base metal.

These features of Electro Paintlok protect the applied finish of completed products—holding it tightly and restricting corrosion to the point of damage if it should be scratched through.

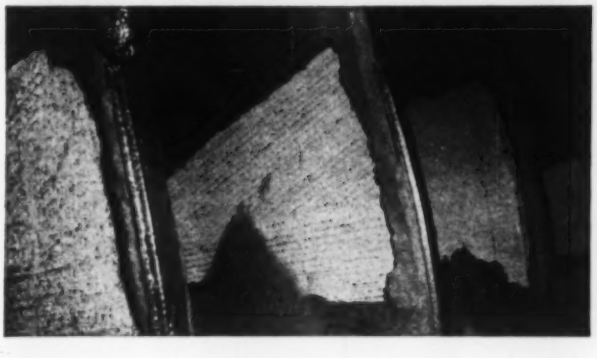
If you want to "build a better mouse trap" in your product field, it will pay you to get all the facts on versatile Republic Electro Paintlok. Contact your Republic representative or mail coupon.



BETTER OVER-ALL PERFORMANCE WAS MADE POSSIBLE through the use of Republic Titanium in the manufacture of these hemispheres by Alloy Products Corporation, Waukesha, Wisconsin. Used for special aeronautical applications, completed spheres provide light weight without impairing safety; strength to contain 2,000 p.s.i.; extreme corrosion resistance to chemically active contents. Beyond providing product advantages, Republic Titanium is easy to draw, pierce, and weld. Little change in fabricating procedure is required as compared with other construction materials. Send coupon for data.

BETTER SERVICE FROM BOLTED ASSEMBLIES subject to impact and vibration can be secured when they are fastened with Republic Nylok® Bolts and Nuts. The resilient nylon pellet imbedded in the body of bolt or nut forces a tight metal-to-metal lock between opposite mating threads. Pellet is unaffected by age or moisture and permits both adjustment and re-use without loss of holding power. Lock is secure even if fastener is not seated. For details, send coupon.

says Mr. E. S. Coughanor,
President, Self Sett
Mouse Trap Company,
Cleveland, Ohio



OPERATION OF THE SELF SETT MOUSE TRAP, as indicated here by Mr. Coughanor, depends on both ingenious design and corrosion resistant materials. A series of automatic doors and pivoted ramps leads the rodent to his destruction in a tank of water. The special coating on Republic Electro Paintlok holds painted finish securely to provide long-term corrosion resistance required to maintain trap operating efficiency.

BETTER COAL "FINE" RECOVERY RATE WAS SECURED when the cotton fabric on this coal-cleaning plant disc-type filter was replaced with a finely woven mesh of Republic ENDURO® Stainless Steel. In addition to doubling efficiency, ENDURO provides far longer service. Republic ENDURO is available in all standard forms, finishes, and analyses. For full information, mail coupon.

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World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
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Please send more information on:

☐ Electro Paintlok ☐ Titanium
☐ ENDURO Stainless Steel ☐ Nylok Fasteners

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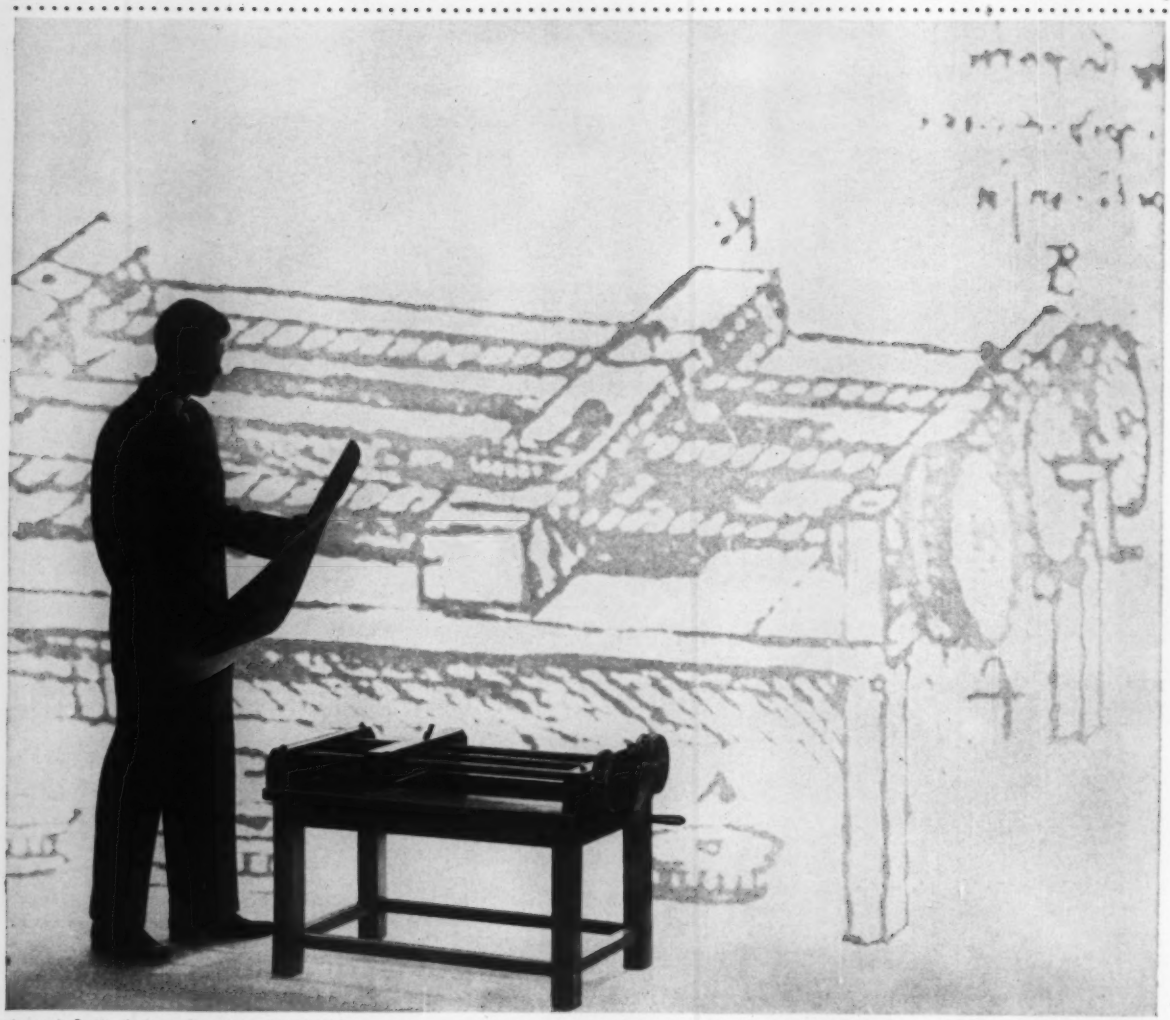
Company _____

Address _____

City _____ Zone ____ State _____

Circle 467 on Page 19

creative designing calls for an open mind



Leonardo Da Vinci's design for a screw cutting machine

Model courtesy of IBM

EVEN THIS DA VINCI DESIGN COULD HAVE BEEN BETTER WITH HELP FROM AN SKF ENGINEER.

The kind of bearings your SKF engineer recommends depends solely on your requirements, not on what he has to offer. That's because the SKF line includes all four basic types of ball and roller bearings in many thousands of sizes. This gives him the kind of flexibility he needs to keep an open mind on any bearing problem. Give your problem to SKF and see.

7832

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE—EVERY USE

SKF

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U. S. PAT. OFF.

protecting products the Caplug way can save you hundreds $$ . . . for pennies spent

quick to put on . . . and quick to take off . . . fit tremendous variety of tubing, threaded fittings and machined parts

Caplugs

take your pick from this big closure family . . . 10 standardized styles . . . over 500 sizes in stock

molded of flexible Polyethylene . . . won't chip, break, shred or collapse

get a free handful of Caplugs like this in exchange for the coupon below

tough enough to take abuse . . . yet, most kind to threads and polished surfaces

CAPLUGS DIVISION, PROTECTIVE CLOSURES CO., INC.
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Mail a free assortment of Caplugs, literature and prices to us, without obligation.

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FIRM _____

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Circle 469 on Page 19

PUROLATOR FILTERS FOR THE PROTECTION OF HYDRAULIC CIRCUITS

G-200M Aircraft Restrictor Filter two-way for hydraulic oil systems metal element

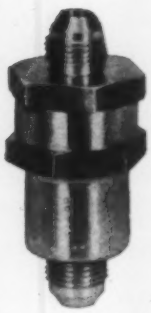
PR 301 ½ GPM line type hydraulic oil filter Micronic element

PR 382 3 CFM in-line vent type Micronic element

G 200 series in-line two-way restrictor filter Metal element, internal connections

PR 312 12 GPM line type filter Micronic element

PR 412-8 12 GPM line type filter Military approval



G-187 3 GPM in-line hydraulic oil filter Metal element

P 32-26 Low pressure, high flow hydraulic oil filter

Effective filtration is essential for optimum performance in hydraulic circuits. To keep a system clean and functioning properly, it is important that the filter be designed specifically to meet the requirements of the job.

Purolator's complete line of filters for hydraulic systems includes models for every set of operating conditions likely to be encountered. A few are shown here; there are many more standard models from which to choose. If your application requires a special filter, Purolator will design and build it. Let Purolator work on your toughest filtration problem.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

Circle 470 on Page 19

RIVETT SQUAREMASTER "100" CYLINDERS

Unfailing POWER for MILLIONS of cycles!

Here's sure power for unfailing cylinder operation. SQUAREMASTER 100's are the world's finest constructed cylinders—perform with 100% efficiency! 200 P.S.I. air to 500 P.S.I. oil. Available in 7 mountings with standard dimensions, in 10 bore diameters, internal and external threading. Special models and cover combinations. Priced competitively; prompt delivery; meet all J.I.C. requirements.

RIVETT, INCORPORATED

Dept. MD-4, Brighton 35, Boston, Mass.

*Initial High Coefficient of Static Friction

POWER-PACKED FEATURES PROTECTED BY POWER-GUARD CONSTRUCTION

1. Piston rod. Ground and polished alloy steel. Hard chrome-plated. **2.** Piston rod bearing. Replaceable cartridge-type. **3.** Piston packing adjusts automatically. V-block packing minimizes friction. **4.** Correctly stressed tie rods. **5.** Cushion bushings. Bronze, floating type. **6.** Ports rotated to any 90° position. **7.** Steel covers. Take minimum mounting space.

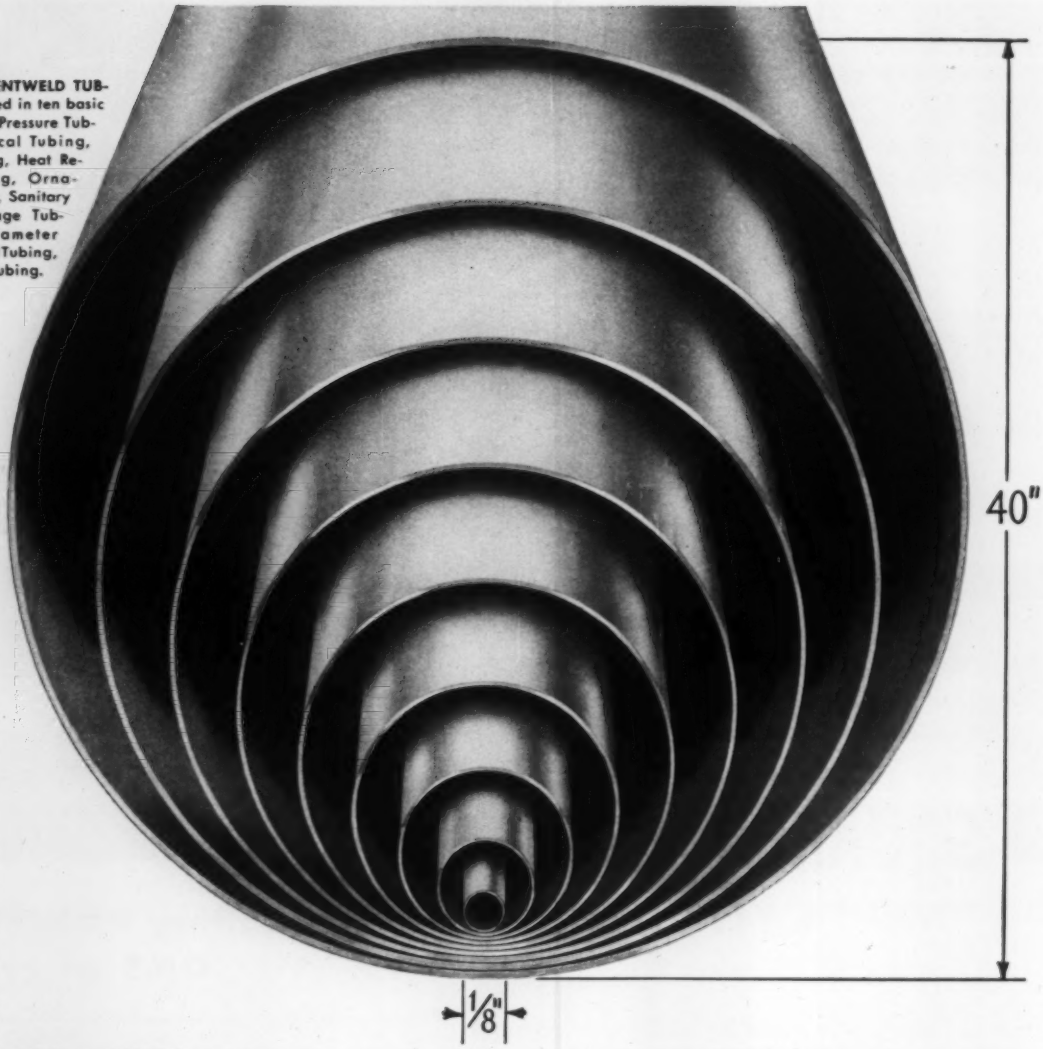
Send for catalog. Proof of SQUAREMASTER efficiency stated in these 20 pages. Write today.

RIVETT furnishes a complete power package

AIR AND HYDRAULIC — VALVES, CYLINDERS, POWER UNITS

Member — National Fluid Power Association

CONTOUR TRENTWELD TUBING is furnished in ten basic classifications: Pressure Tubing, Mechanical Tubing, Aircraft Tubing, Heat Resistant Tubing, Ornamental Tubing, Sanitary Tubing, Beverage Tubing, Large Diameter Tubing, Shaped Tubing, and Formed Tubing.



TRENTWELD tubing is equal in strength and has more uniformity than tubing made by any other method of manufacture

Trent offers tubing in sizes ranging from ⅛" to 40" O.D. and in a wide range of grades. These include: Hastelloy,* Zirconium, Zircaloy, Titanium and 19-9-DL grades. All are made by an exclusive welding process—Contour Trentweld®—which virtually eliminates the bead. Furthermore, by cold working and annealing after welding, Trent makes the weld equal in strength and corrosion resistance to the parent metal.

To insure that Trentweld tubing is of the highest quality attainable, a rigorous quality control program is carried out. Samples of each lot are tensile tested. Periodic tests — flattening, reverse bend, flare and flange, coil, and pressure — are conducted. Rigid corrosion tests are made on all lots intended for corrosive applications. When requested, a unique "single-wall" X-ray inspection is made as your final assurance of a sound, uniform product.

Why not take advantage of Trent *quality* when you order stainless or high alloy tubing? For further information, write for the Trent tubing handbook, Trent Tube Company, East Troy, Wisconsin.

*Trademark of Haynes, Stellite Co.

CONTOUR TRENTWELD

TRENT TUBE COMPANY

Subsidiary of Crucible Steel Company of America

GENERAL OFFICES: EAST TROY, WISCONSIN
MILLS: EAST TROY, WIS.; FULLERTON, CALIF.

Circle 472 on Page 19

PRODUCTION
at its peak ---

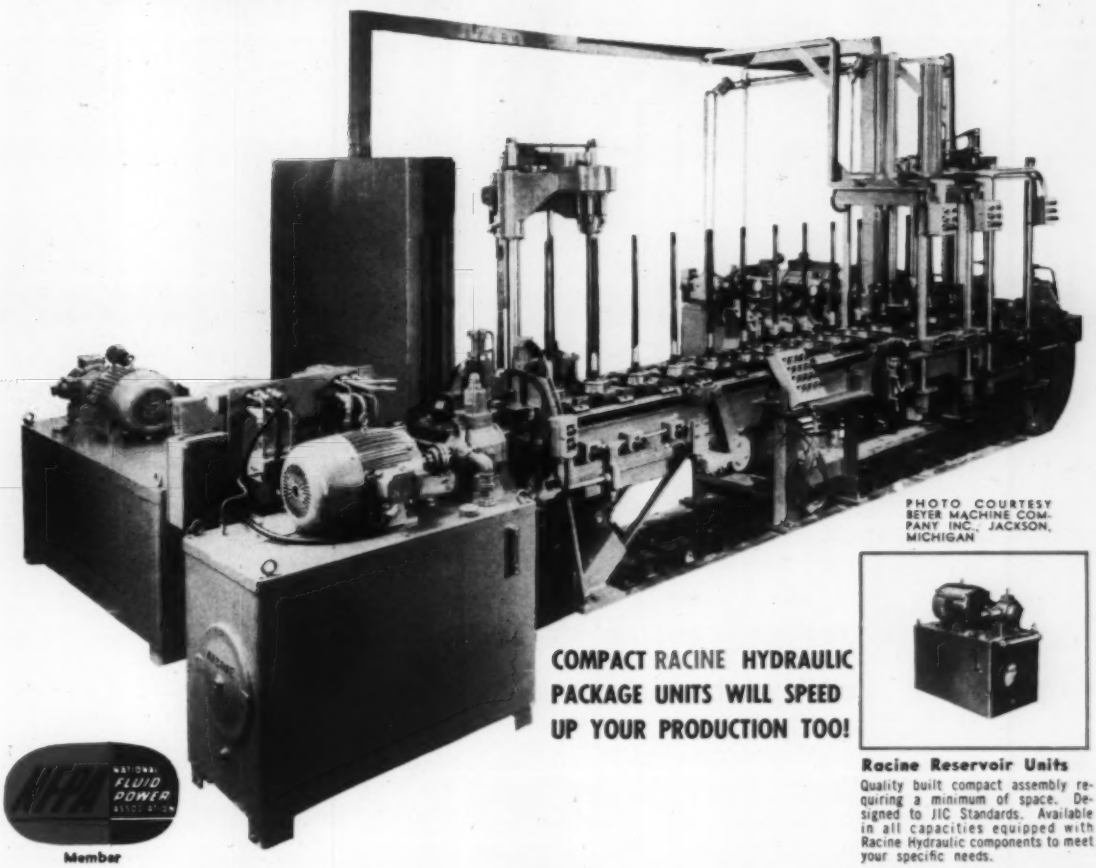


PHOTO COURTESY BEYER MACHINE COMPANY INC., JACKSON, MICHIGAN

COMPACT RACINE HYDRAULIC PACKAGE UNITS WILL SPEED UP YOUR PRODUCTION TOO!

Racine Reservoir Units

Quality built compact assembly requiring a minimum of space. Designed to JIC Standards. Available in all capacities equipped with Racine Hydraulic components to meet your specific needs.

NFPA NATIONAL FLUID POWER ASSOCIATION
Member

Through the use of RACINE hydraulics

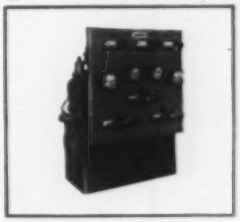
9 OPERATIONS (One Axle) EVERY 8½ SECONDS

This is one of the many excellent examples of hydraulic application to modern production machines. Through the use of RACINE hydraulics, nine, oil cushioned, smooth and positive, controlled axle machining functions are accomplished.

They include chamfering of five holes; staking five studs, pressing and inspecting bearing and dust guard, pressing and inspecting retainer and polishing and unloading. All sequences are controlled and operated with maximum precision and economy.

Investigate Racine's FREE Engineering Service.

Write us about your needs, and request catalog PB-1.



Racine Power Panels

Designed to your specifications. Compact with maximum accessibility for quick and easy servicing of all equipment, piping and wiring. Designed to JIC Standards.

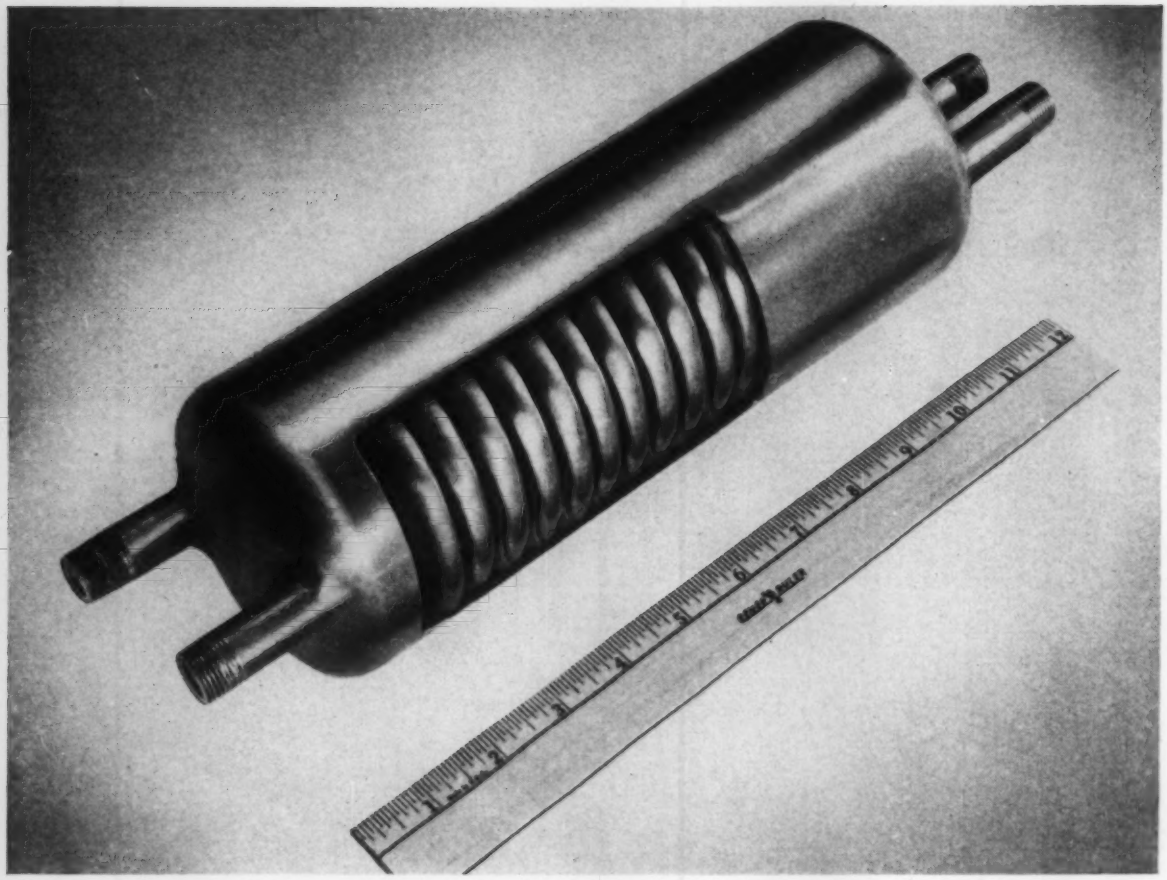
RACINE — STANDARDS FOR QUALITY AND PRECISION — RACINE HYDRAULICS & MACHINERY, INC. — SECO

RACINE HYDRAULICS & MACHINERY, INC.

2073 Albert Street RACINE, WISCONSIN

Simplex Engineering Company, Subsidiary, Zanesville, Ohio

Circle 473 on Page 19



Uniformity and Workability Make Carpenter Welded Tubing Better for New Cooler

The inventor of this new, low-cost liquid sample cooler selected Carpenter Welded Stainless Tubing (Type 316) because of its uniform wall thickness, high ductility and excellent working qualities.

This shell and tubular type cooler is designed around ¼" O.D. x 20 ga. material for use with pressures up to 5,000 psi. or temperatures up to 1200°F. It is applicable to atomic power plants, feedwater heaters, hot water softeners and both high and low pressure boilers in power plants.

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Circle 474 on Page 19

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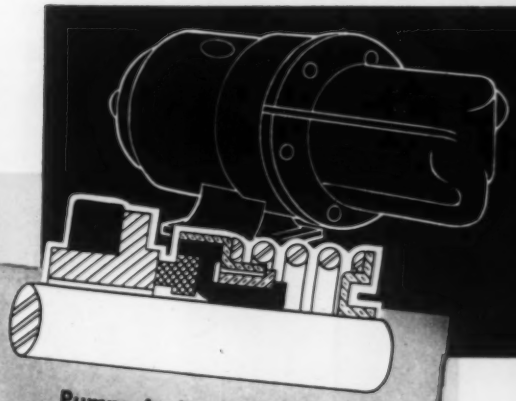

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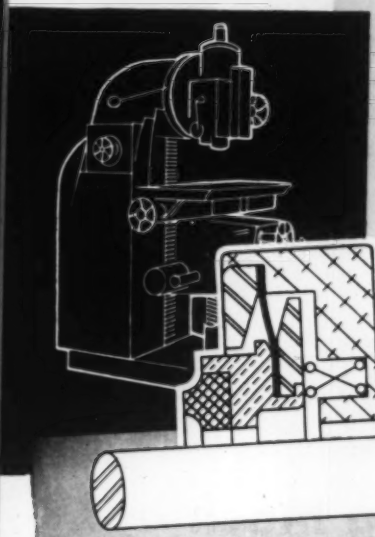

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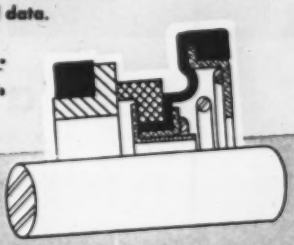

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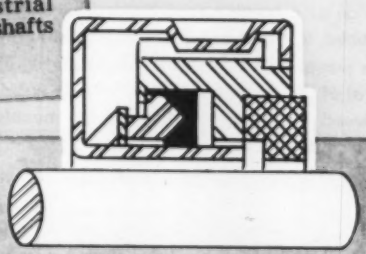

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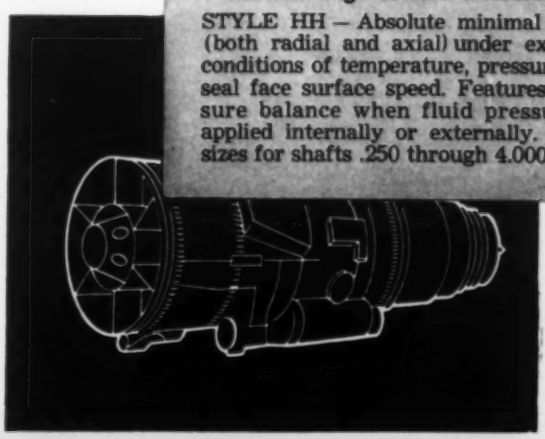
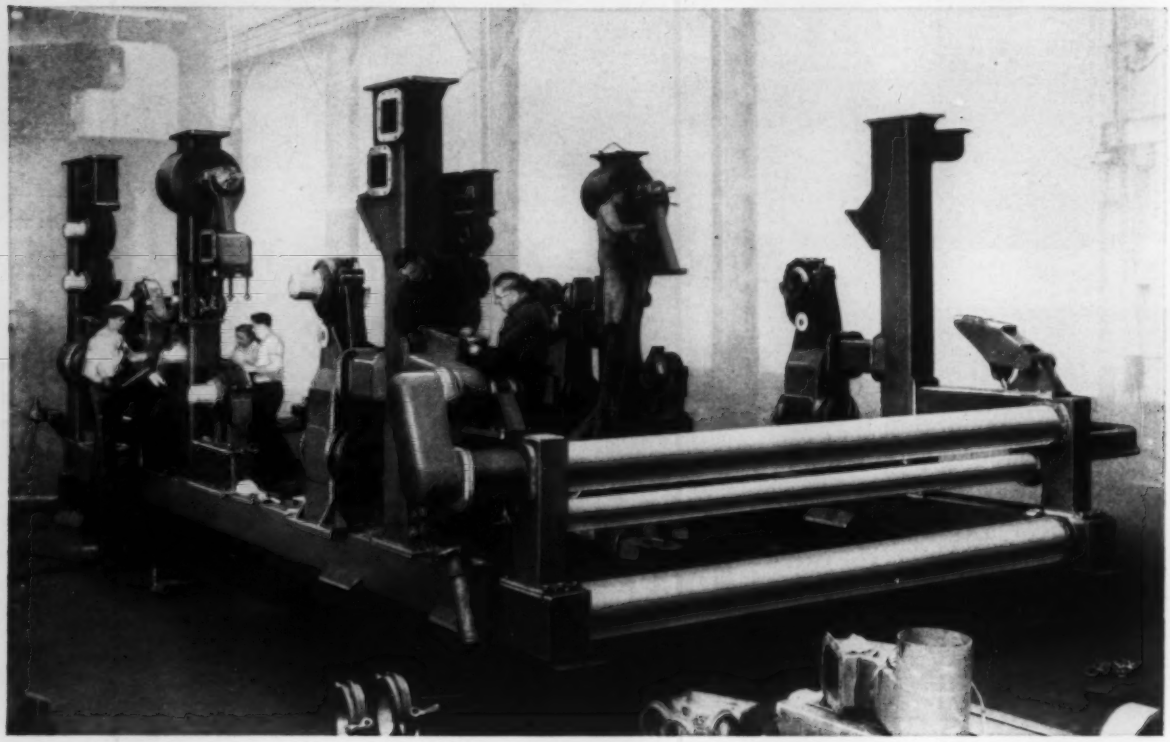


Circle 475 on Page 19

STEEL-WELD FABRICATION . . .



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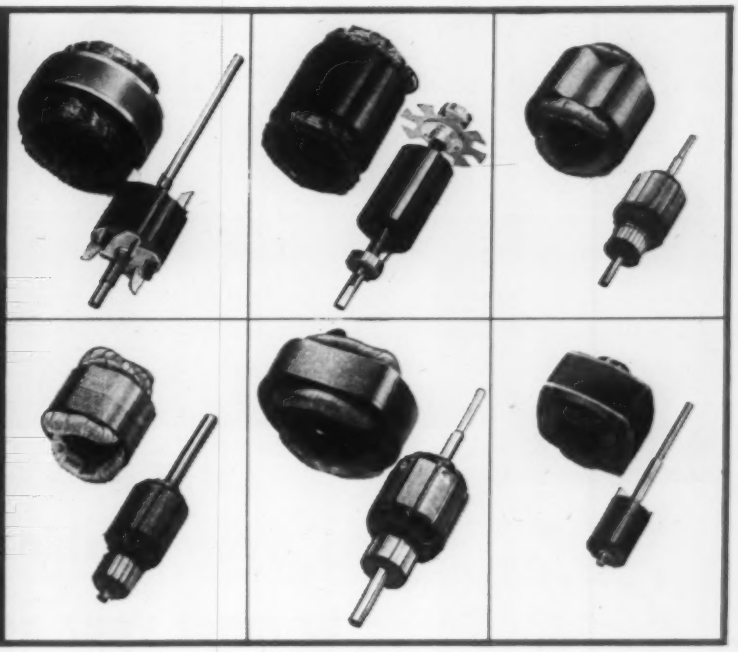

Illustrated here are a few of the motor parts sets in the complete Howard line. They are currently handling the power requirements of portable power tools, floor polishers juice squeezers and thousands of other widely varied applications. Designed to be built directly into the housings of products and appliances, Howard Motor Parts Sets include armatures and fields, brushes and brushholders, rotors, stators and fans—in any combination, as needed. Whatever your application, there is a standard Howard parts set or variation to match your specifications. If your requirements are in the range of ratings from 1/200th to 1 H.P., check with Howard today.

Now also exclusively available from Howard are the former Westinghouse Motor Parts Sets. Contact Howard for samples and specifications.

SPECIFICATIONS

ARMATURES					COMMUTATORS		
Parts Set No.	No. of Slots	Outside Diameter	Inside Diameter	Core Sizes Available	No. of Bars	Insulation	Hubs
11A	11	1.375	¼ ⅝	⅝, 15/16, 1, 1¼	11 or 22	paper, mica, bakelite, or nylon	molded or steel
150	12	1.379	⅛	⅜, 1, 1¼, 1½	24	paper, mica, bakelite, or nylon	bakelite or steel
200	8	.960	¼	⅜, ⅝, 15/16, 1	16	paper or mica	steel
500	12	1.506	.359	¾, 1, 1¼, 1½	24	paper or mica	steel
700	14	1.812	⅛ ½	1¼, 1½, 1¾, 2	28	paper	steel
900	13	1.600	⅛	1¼	26	paper or mica	steel
2700	7	1.380	¼	1, 1¼, 1½	7 or 14	paper or mica	steel or bakelite

ALL MODELS:

SHAFTS:
Shafts are ground from centers for concentricity. Special flats, worms, etc., can be cut on shafts if required. C.R. Steel is normally used, however stressproof or various types of stainless steels can be furnished if desired.

INSULATION:
Armatures have a fiber end insulator at both ends of the steel laminations. The inside of the slot is insulated with varnished cambric. The armature is wound with heavy formvar copper wire.

LAMINATIONS:
Laminations are stamped in sets from 24 or 26 gauge improved electrical sheet steel. They are riveted together under pressure in an expanding die. The outside diameter of the field can be ground to customer's specifications. Field coils are wound with heavy formvar copper wire, taped with cotton rayon tape, inserted in field core, then double dipped and baked in an insulating varnish. Field leads can be cut to desired length.

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Circle 477 on Page 19

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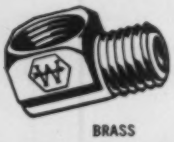

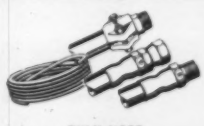

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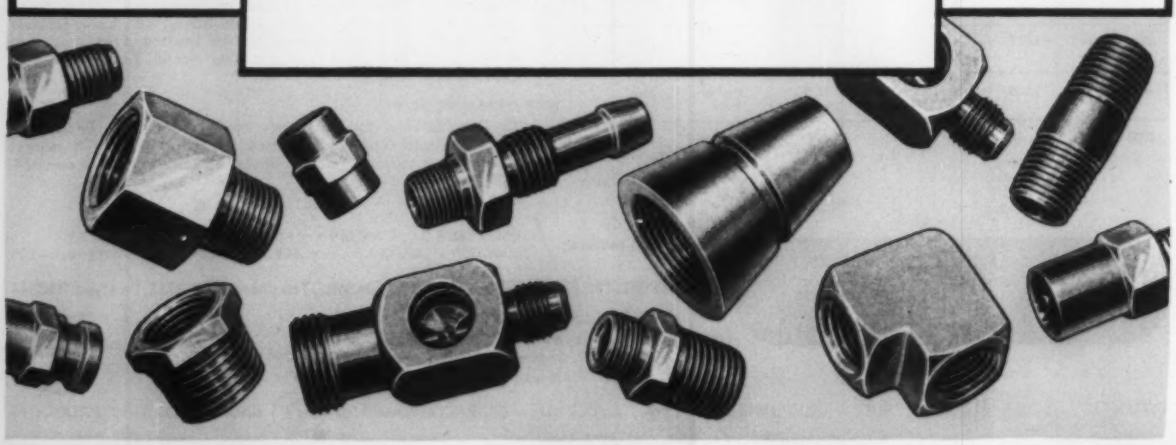


DESIGN
April 17, 1958

Unity—at a Price

IF surveyed, most engineers undoubtedly would say that they want unity within the profession. But are engineers—individually and as members of engineering societies or organizations—willing to pay the price?

Most recent in a long succession of plans for unity is the one proposed by AIEE. In many ways it is an excellent plan in which the significant and worthwhile values of present engineering groups are retained, strengthened, and effectively used.

As is well known, the plan calls for three different areas of activity, each headed by a presently existing engineering group. Engineers Joint Council would co-ordinate "technical" activities; Engineers' Council for Professional Development would handle "educational" activities; and National Society of Professional Engineers would be responsible for "professional" activities.

This plan—or any unity plan—requires sacrifice. EJC would probably have to curtail activities in the fields of employment conditions, labor legislation, practice of engineering, and social security legislation. ECPD might have to slow down in the field of engineering practice. NSPE would probably have to retrench in technical education. Additionally, to broaden its representation, NSPE might have to change its membership requirements to open its ranks to unregistered but technically qualified engineers.

These sacrifices don't come easily. For some of the senior men thoroughly steeped in individual society or group activity, they are bitter pills to swallow. For instance, the comment of one NSPE member at a recent meeting typifies this rigid thinking: "Why should we 'bend' our entrance requirements; let them come to us." Similar inflexible statements could be made by individual representatives in every engineering group concerned.

Any unity plan is going to require a lot of "give and take." Let's not forget, though, that the "giving" occurs before the "taking." This is the price we will have to pay to get any plan for unity off the launching pad.

Robert L. Stedfeld

ASSOCIATE MANAGING EDITOR

Human-Factors

MAN AND

By JOHN D. VANDENBERG
Occupational Research Center
Purdue University
Lafayette, Ind.

Man stacks up poorly against his machine creations in speed, power, and durability. This poor showing explains his minor status as a power-generating and transmitting device. Even when the job demands little muscular effort but, instead, the exercise of subtle control functions, the system designer has learned not to depend strongly on man's unflagging attention and precision of response.

Yet, despite these obvious shortcomings, man isn't seriously threatened with obsolescence. Certain unique qualities—including judgment, reasoning power, and flexibility—guarantee his continued use in man-machine systems. How efficiently he functions depends upon whether or not such plus qualities are overworked.

Human-factors specialists—backed up by quantitative data provided by experimental psychologists—are trained to match men and machines for optimum efficiency. Where the system-design problem is unusually complex, it may be desirable to engage such an expert. Often, however, straightforward problems involving man-machine interaction can be handled by an engineer who is not a human-factors specialist, but who is well grounded in the techniques and standard solutions of the subject.

Presented here is the introductory article of a series organized to provide a human-factors background for the designer contending with human limitations and capabilities. Emphasis centers on defining areas of human-factors activity and showing how these areas fit into the over-all design picture. In following articles, attention shifts to more specific topics. Among these are vision and its effect on display design, hearing, muscular performance, and body dimensions, all considered in their relationship to man-machine system efficiency.

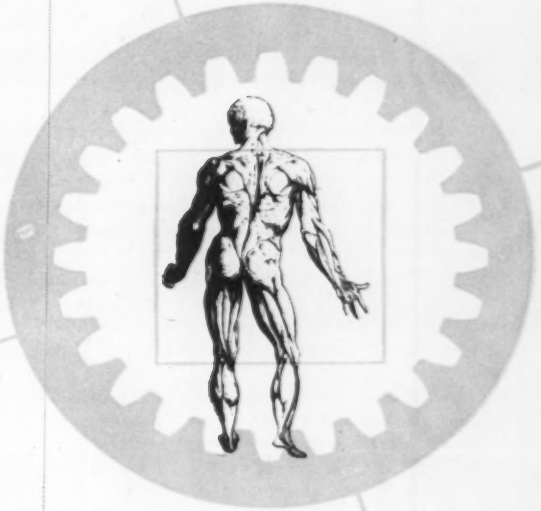
THE concept of man and machine interacting as system members represents a relatively new philosophy in design. Broadly interpreted, the term "machine" refers to any object used by a human being to accomplish a task; the man-machine system consists of man and machine working to attain a common goal. How efficiently this is done depends on how successfully the designer matches the demands of the machine to the capabilities and limitations of the man.

Modern machines are more accurate, faster, and more durable than their predecessors. They call on the more subtle attributes possessed by their human operators for satisfactory performance. As a result, instinctive "common sense" is no longer the entirely reliable human-factors design guide that it has been considered in the past. Because quantitative data on human performance may be lacking—and common-sense ideas usually spring from such data—solutions to design problems may be missed.

To cite a simple example: Aircraft designers long knew that a cockpit should be dark so that the pilot could see outside. But how to read maps and instruments in a dark cockpit? Common sense failed to

Engineering—1

MACHINE



indicate that red lighting—which preserves dark adaptation—was the answer. To the present-day designer this now seems only common sense. Nevertheless, it was first discovered by scientific inquiry.

Another difficulty with over-reliance on common-sense design solutions is introduced by the continual change taking place in so-called common-sense ideas. For example, it may seem reasonable to assume that a machine operator's visual acuity will serve him equally as well in one task as in another. Yet it has been demonstrated that a man may see distant objects well and near objects poorly, or the opposite. And, more astonishingly, it has been found that there is little relationship between the ability to see stationary targets as compared to the ability to see moving targets.[1] This points up that it is probably good policy to avoid a design solution where the operator is required to see, at different times, both near and distant objects, stationary and moving objects. Such a situation may give rise to the problem of finding operators who possess the visual acuities that would allow them to operate efficiently in the man-machine system.

[1]References are tabulated at end of article.

The Human-Factors Concept

The foregoing discussion is, of course, not intended as an indictment against the use of common-sense in machine design. In fact the broad area of activity that has come to be called "human-factors engineering" may be thought of as an augmentation, correlation, and extension of fundamental ideas implicit in the common-sense approach.

Through combination of definitions presented by the author[2] with those of Peters and Seminara[3], human-factors engineering may be defined as en-

De Humani Corporis Fabrica

The muscular structure of man shown on this issue's front cover is adapted from a wood-block illustration by Andreas Vesalius from his book **De Humani Corporis Fabrica.** Vesalius, an early student of anatomy, was one of the first to show the body's internal structure; the plates in his Second Book, which show the body successively stripped of its muscle layers, have been studied by artists and physicians for 400 years. The illustration is adapted from **Andreas Vesalius of Brussels** by J. B. de C. M. Saunders and Charles D. O'Malley, World Publishing Co.

compassing those activities that place special emphasis on attaining the *optimum mode of interaction* between men and machines, thereby insuring the efficient operation of a system.

To bring about such man-machine efficiency, three areas of activity are stressed: 1. Design of human tasks. 2. Design of machines in terms of human capabilities and limitations. 3. Development of knowledge that will facilitate the first two factors.

In the past, it was common procedure to design with virtually no systematic consideration of the capacities of machine operators or users, Fig. 1. After the machine was built, operators were selected and trained to run it. The design engineers paid little attention to human factors; the personnel man, concerned with selecting and training operators, paid little attention to design and development problems. It is fair to say that both individuals considered their respective specialties as almost independent.

From this point of view, the machine was considered the constant factor, and the human operator was considered a variable factor that had to adjust to the unique conditions presented by the machine. In human-factors engineering, the opposite viewpoint is stressed: Man is considered the constant, and machine is the variable that is designed to be compatible with man's capabilities and limitations. As a further advance, a dynamics systems concept replaces the earlier, static viewpoint of man and machine interaction.

The usual criteria of good engineering design naturally remain, now augmented by the idea that the end purpose to be served by the man-machine system is paramount.

Human-factors engineering is an interdisciplinary activity. The key members of any large-scale human-factors engineering team are a design engineer and a psychologist. The engineer exercises final authority over the progress of the work and contributes his knowledge of the engineering aspects of the system under development. The psychologist contributes both his knowledge of how the human organism functions and his ability to design meaningful experiments using human subjects.

To an increasing extent in the military, the fighting man—the consumer of the "goods"—contributes valuable ideas while an item is in the research and development stage. Depending on the nature of the problem, representatives from a wide variety of disciplines may contribute their knowledge and skills to the project. In addition to the various branches of engineering and psychology, the fields of anthropology, physiology, medicine, mathematics, and physics make significant contributions.

How It Started

Prior to World War II, most attempts to improve the operation of man-machine systems by designing machines to fit the operators were based on experience rather than experimental evidence. A variety of new radars, sonars, and range finders were introduced and, to the alarm of their designers, failed to perform in the field as they had during engineering and acceptance tests. Investigations were made to determine the cause of the shortcoming. It was found that such machines taxed sensory and/or motor capacities of operators, requiring sensory discriminations that few people could make, or control motions that only the most dexterous could perform. In other words, the machines exceeded the natural capabilities and limitations of the majority of prospective operators.

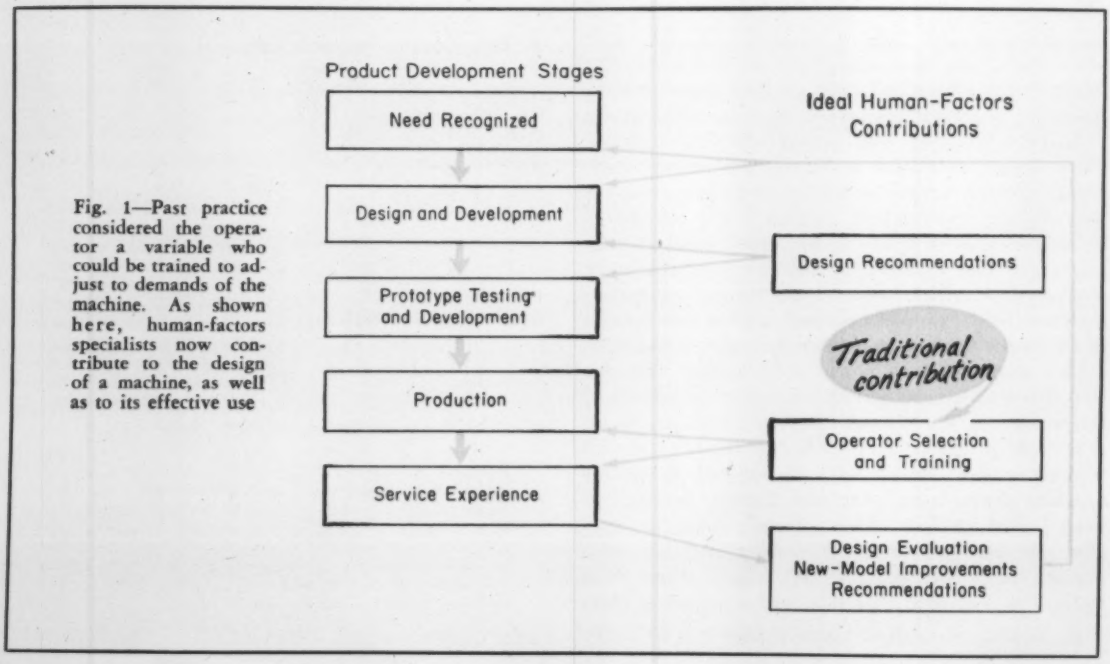


Fig. 1—Past practice considered the operator a variable who could be trained to adjust to demands of the machine. As shown here, human-factors specialists now contribute to the design of a machine, as well as to its effective use

However, experimental psychologists had long been gathering information concerning the sensory and motor capacities of human beings. People with such knowledge and skills were asked to make recommendations for the redesign of equipment which would not exceed the natural abilities of the majority of operators. The success of these pioneer efforts was remarkable, and it was quickly realized that improvements could probably be made in other items which appeared to be operating properly. This proved to be the case, and by the end of the War a number of people were engaged in what had come to be known as human engineering.

In following years, the military continued its human-factors engineering efforts, and the Army, Navy, and Air Force established research centers to obtain additional information applicable to the design of military machines. Specialists were assigned to work directly with the design engineers at a number of installations. Consulting organizations also took up this work and offered their services to both the government and private industry. Military services now include a clause similar to Table 1 in their procurement contracts that requires the adequate and timely consideration of human factors problems that may be encountered in the course of research and development work on military items.

The problems have not all been solved, however. The Air Force reports a number of instances where the requirements of a job exceeded human strength capacities. During the period from January, 1949, through December, 1953, there were 42 fatal accidents in jet trainers when the altitude of the aircraft at the time of an emergency should have allowed successful escape from the plane. However, in none of these cases did the pilot leave the airplane. Evidence of what happened was provided by interviewing pilots who first unsuccessfully attempted to bail out, and then regained control of the plane.

Table 1—Military Human-Factors Specifications

In all phases of the study, design, and development of systems and equipment called for in this specification, the contractor will utilize the services of a human engineering specialist or specialists in determining the existence of and solution to problems in: 1. Space for operators' stations in the arrangement and design of controls. 2. Design of visual displays and other means of supplying information. 3. Safety features. 4. Environmental conditions such as illumination, noise levels, vibration, temperature, and ventilation. 5. Utilization of skills already existent in available crews for improving the overall effectiveness of the system. The contracting officer will provide a list of approved sources for such services. Upon request, additional sources may be approved by the contracting officer.

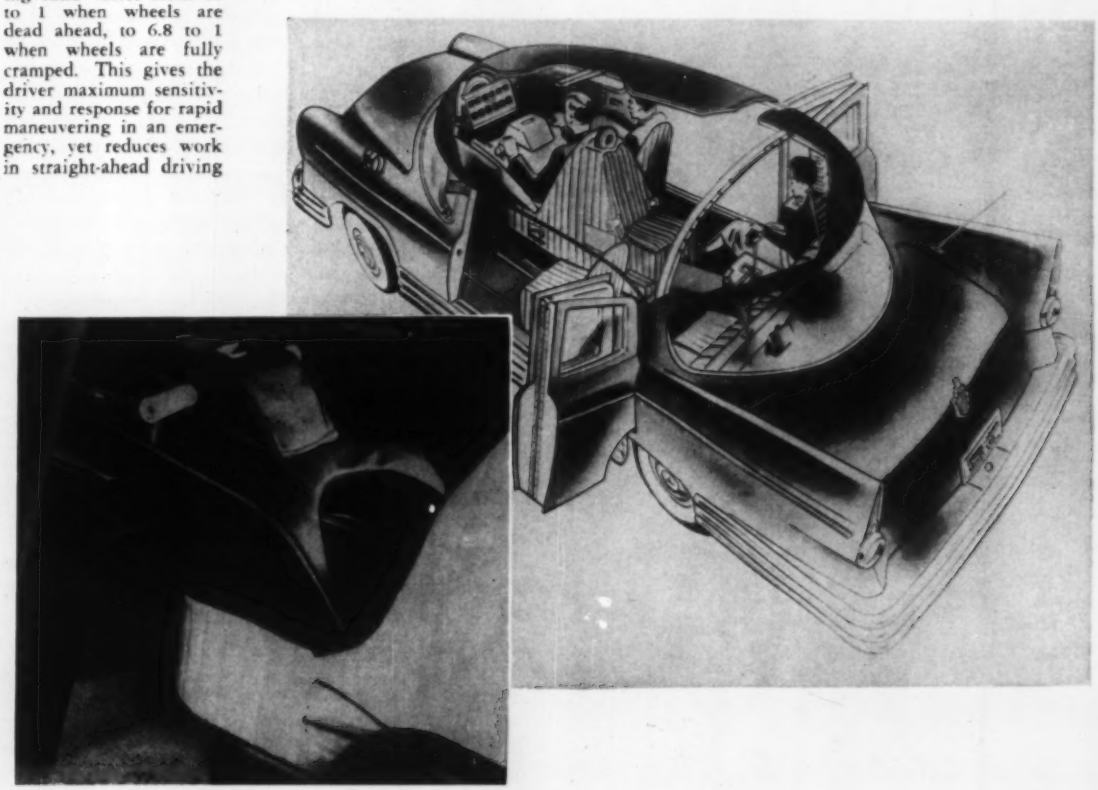


Fig. 2—Safety considerations are paramount in this Cornell-Liberty experimental car. Steering handles, which replace the potentially lethal steering wheel, plus an adjustable chest cushion, guard the driver against chest-impact forces. Steering ratio varies from 15 to 1 when wheels are dead ahead, to 6.8 to 1 when wheels are fully cramped. This gives the driver maximum sensitivity and response for rapid maneuvering in an emergency, yet reduces work in straight-ahead driving

or survived a crash landing. In the aircraft model in use, it was necessary to reach up to pull the canopy jettison lever. The acceleration forces generated by the wildly gyrating plane were so great that the pilots could not raise their arms to actuate the lever. The Air Force recognizes that many of the 42 pilots were probably lost because of this.

Because virtually all military work is classified, industry has been slow to adopt and make use of military human-factors engineering advances. Some important nonmilitary work has been done, however, and there is little doubt that increased emphasis will follow now that the practicality of the techniques has been demonstrated.

Current Examples

A continuing program being conducted by Dr. Ross McFarland, Harvard School of Public Health, has the aim of improving the safety of operation of cars, busses and trucks. Human-factors engineering is one primary area that is being stressed in this comprehensive research program.

To increase driver comfort and safety, careful consideration has been given to the development of seat design, design and location of dashboard instruments, design and location of various controls, and the requirements for adequate vision, both forward and backward. It is apparent that the safety of motor vehicle operation can be improved markedly through application of human-factors engineering principles, and some of the commercial users of this equipment (who partially support the Harvard work) are planning to make use of Dr. McFarland's results. Another safety automobile project, jointly supported by Liberty Mutual Insurance Co. and Cornell Aero Laboratory, is illustrated in Fig. 2

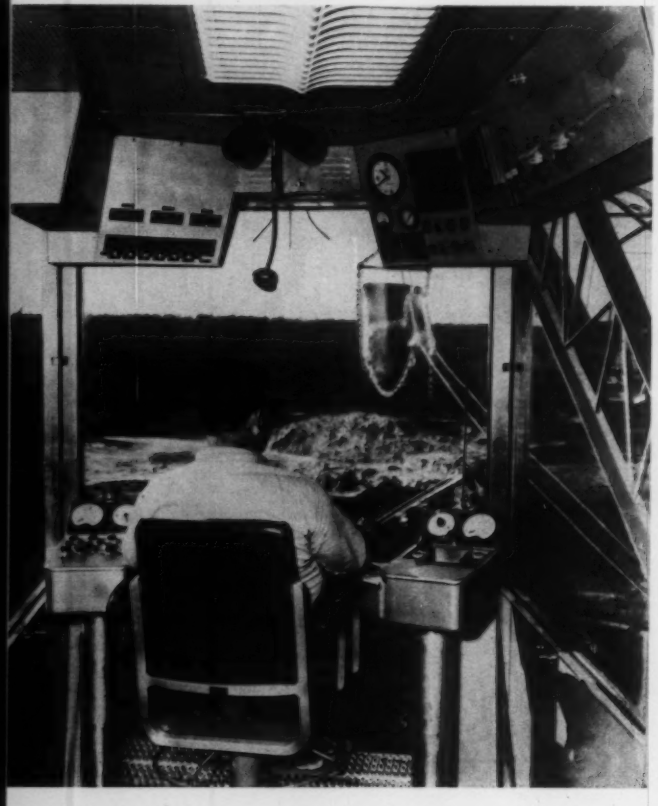
Application of human-factors engineering principles to passenger automobiles may have to await dilution of the public's current emphasis on interior and exterior styling. For example, one automobile designer, who shall remain anonymous, is supposed to have said: "We know better than to build a car so that the instrument panel reflects in the windshield, but any other arrangement would not look as nice. We have to make cars that are attractive since this is what the public wants."

Automobile manufacturers can often incorporate human-factors engineering recommendations into new models only at the peril of losing part of the market. Another deterrent to the inclusion of safety devices is the suggestion that the car is not safe and needs these devices. This conclusion on the part of the prospective buyer might be instrumental in his selecting a competitor's model.

The International Minerals and Chemical Corp. has experimented successfully with human-factors engineering in the design of control cabs in huge draglines, Fig. 3. These machines are the heart of a phosphate strip-mining operation in Florida. The old cab design required the operator to sit on a bicycle-type metal seat, exposed to the elements, and simultaneously operate numerous controls with both hands and feet. On occasion, it was also difficult to see where the bucket was dragging or to communicate with other members of the mining crew.

A human-factors engineering study by Dunlap and Associates Inc., Stamford, Conn., resulted in recommendations for a control-cab design that would overcome the deficiencies observed in the existing cab. The redesigned cab provided the dragline operators with a comfortable, adjustable seat, more easily operated controls, and improved visibility and communications. Operators who have had experience with the new cab express a reluctance to operate in the older versions. It has been estimated that a 7 per cent improvement in the operation has been realized with the new cab.

Fig. 3—Control cab of this giant dragline includes many features recommended by human-factors engineers



Three Areas of Effort

The following specialized activities within the broader framework of human factors engineering can be identified:

1. Human-factors applications.
2. Human-factors research.
3. User liaison.

This article series is concerned primarily with human-factors application, that is, with the applica-

tion of psychological principles and data to equipment design problems.

There is not yet unanimous agreement concerning the background of training and experience most appropriate for the execution of application, research, and liaison duties. The field of human-factors engineering is still so new that people with a variety of backgrounds are engaging in all or various combinations of these activities. Except in the very large human-factors organizations, this situation will probably exist for some time. Ultimately, however, it is reasonable to assume that the pattern outlined in following sections will emerge.

Human-Factors Applications: Engineers who have completed courses in human-factors engineering can logically be expected to integrate these skills into their repertoires and to carry out human-factors engineering along with their other duties. There are about 25 schools in the country that presently offer one or more courses in human-factors engineering, either to undergraduate or graduate engineering students. Such formal programs can be expected to increase in number as the pressing need for people to work in this area becomes better known to educators. Within the next five years, the supply of engineers capable of dealing with the jargon of psychology and who have the time, inclination, and abilities to deal with human-factors engineering problems can be expected to increase. Some engineers, largely self-educated in human-factors engineering, are now doing an excellent job. However, it is not expected that sufficient numbers will become acquainted with the field without encouragement.

An excellent monograph concerning the prosecution of research studies involving people has been prepared by Chapanis.[4] It is written for engineers and other technical specialists who lack an extensive background in psychology, but who are required to perform or interpret the results of experiments involving men and machines. This report serves as a good starting point for anyone interested in learning more about this phase of the activity.

Peters and Seminara[3] have suggested that the term "human-factors engineer" be reserved for graduate engineers who are concerned with applications problems. They further suggest that people from other disciplines doing this sort of work be called "human-factors consultants."

Human-Factors Research: Human-factors research will undoubtedly remain the exclusive domain of psychologists and members of allied disciplines. Personnel engaged in more basically oriented research activities will be those who have the doctorate (or its equivalent) in their fields and who have had training in the more refined techniques of experimenting with human subjects. The "human-factors research specialist" (as Peters and Seminara have suggested these people be called), although remaining in close contact with operating problems, will be primarily concerned with conducting controlled studies, either in the human-factors laboratory or in the field.

User Liaison Activities: User liaison groups, which are becoming more common, serve two primary functions. First, they examine existing products to determine whether improvements can be made from the human engineering standpoint. Resulting improvements may be made either on new models of existing equipment, or in completely new designs of similar equipment. Second, field liaison groups serve as feed-back channels through which information concerning the adequacy of human-factors engineered designs can be evaluated and utilized as a guide to product redesign.

User liaison, as a formal undertaking, represents the most recent development in human-factors engineering. No one has yet specified the education and experience background required for this sort of work. The Army is taking steps to provide some liaison training to officers of combat arms and technical services who must use equipment. This training will place them in a position to evaluate equipment more adequately from the human-factors engineering standpoint and to identify those aspects that might be improved.

When the nature of the product is such that a user liaison team (or teams) will serve a useful function, the procedure of using specially trained people seems to be the best method to follow. However, operating people, even when trained, cannot always be relied upon to look critically at the human-factors engineering side of an operation. It is then likely that such observations will revert to the industrial psychologist who is able to conduct interviews, perform job analyses, and determine consumer preferences. Skill at conducting interviews and constructing questionnaires is essential, since it is often necessary to obtain information by means of these techniques. The ability to carry out a job analysis is helpful, since it is often impossible to obtain the desired information by means of either interviews or questionnaires. Some knowledge of the engineering principles applicable to the equipment in question is also required, since clues as to what can and cannot be done by way of improvement often come from such knowledge.

It is unlikely that many individuals will be found who possess all of these skills. As an alternative, liaison activities can be carried out by a team of individuals who, together, have all the requisite skills.

In the next article of this series, design of man-machine system elements is investigated from the standpoint of operator visual efficiency. Visual displays—both quantitative and qualitative—are evaluated for ease of reading and interpretation.

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3. G. A. Peters and J. L. Seminara—"Alias the Human Engineer," *Navy Human Engineering Bulletin*, Feb., 1957.
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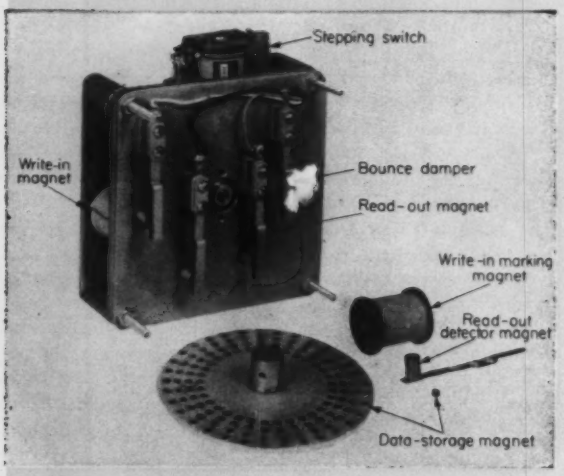
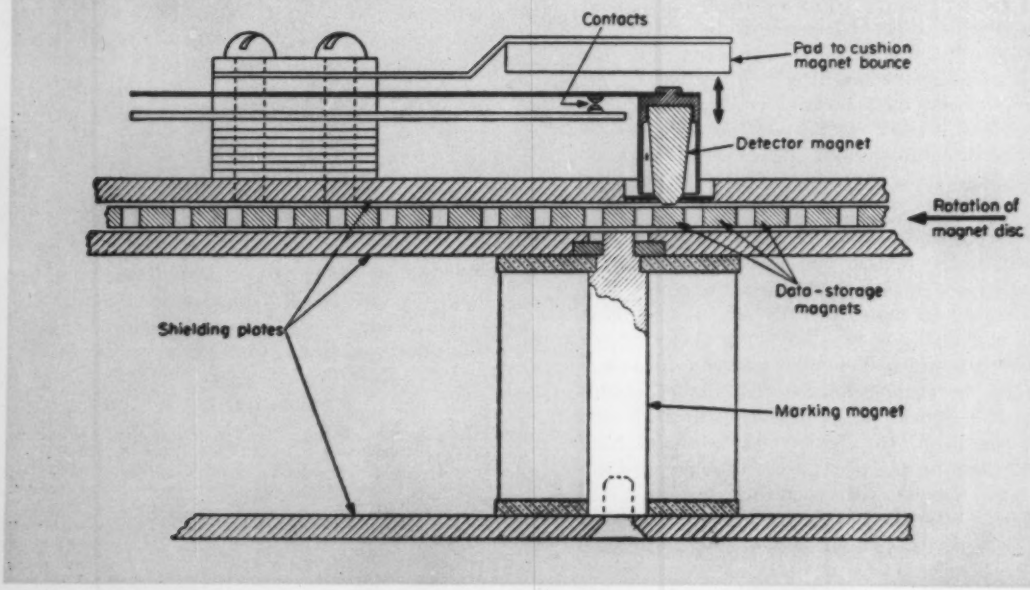
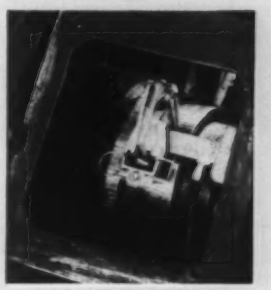
scanning the field for *ideas*

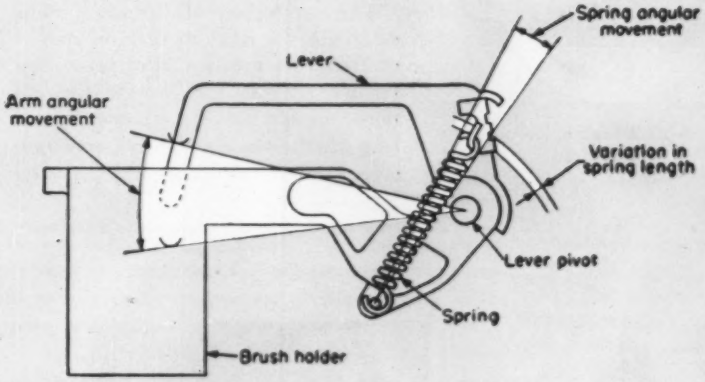
Permanent-magnet memory system provides compact data storage without electrical hardware normally associated with conventional devices. The Madget register, developed by General Telephone Laboratories Inc., is based upon utilization of the residual flux in permanent-magnet materials. Each of a number of magnets embedded in a rotatable disc is individually "marked" or magnetized by a write-in head. Residual flux of the magnet holds this stored data until the polarity of the magnet is detected by a permanent-magnet read-out device. The magnetic characteristic of the magnet, as imparted by the marking head, either attracts or repels the read-out magnet. This force is utilized to mechanically open or close contacts to complete the read-out function. The stored information may be retained and read later, read a number of times, or automatically erased by replacing it with an opposite marking.





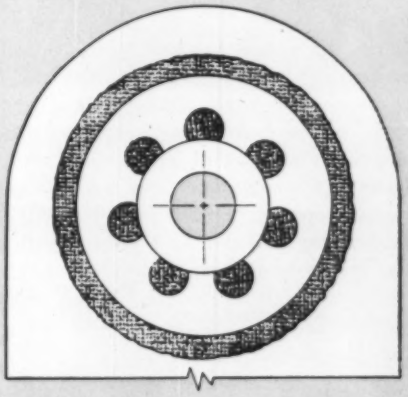
Constant-force output through wide angular movement of a linkage lever is provided by an extension spring. Developed by John W. Erickson, Motor Engineering, Westinghouse Electric Corp., the design is used in a brush holder to furnish a nearly constant force against the commutator brush. Force is applied to the brush by one end of the lever; the actuating spring is fastened to the opposite end. Due to the geometry of the spring, lever, and lever-pivot designs, the spring force increases as the moment arm of the lever decreases, resulting in a virtually constant moment for an appreciable angular movement.

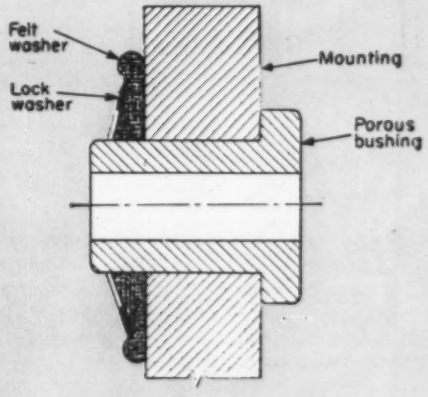


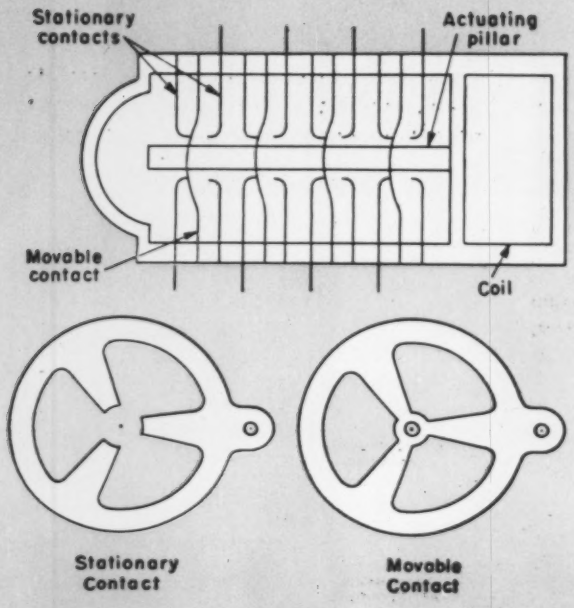


Two-piece washer assembly serves as combination locking fastener and oil reservoir for through-hole mounting of headed parts or parts with a locating shoulder. Consisting of a felt washer and an internal-type, tooth lock washer, the assembly was designed by Macey Co. for application to a porous-metal bushing.

Oil holes and other conventional oiling techniques are replaced by the felt washer that surrounds the bushing and is retained by the lock washer, which also holds the bushing in place. The design leads to low-cost assembly.

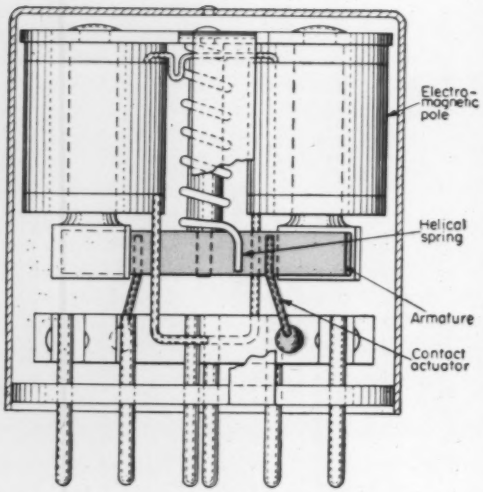


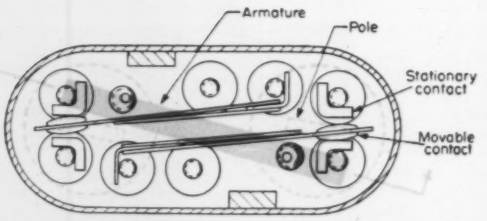


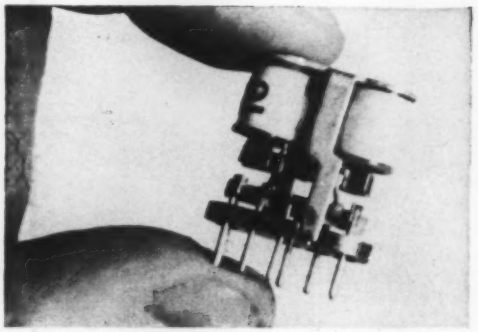


Redundant contact surfaces increase reliability of switching mechanism under conditions of extreme vibration and adverse environment. Developed by Jennings Radio Mfg. Corp. for a dry-circuit relay, the design employs a "stack" of rings, each with three internal arms. The ends of the arms on part of the rings are bent downward—these are the stationary contacts. Located in the center of the ring is an actuating pillar which grips the arms of the remaining rings; when flexed by axial movement of the pillar, these arms serve as movable contacts.

The multiplicity of contacts permits designing the rings so that resonances of the arms are dissimilar, providing reliability under high-vibration conditions. In addition, the contacts are all in parallel, assuring effective operation even if some fail to operate properly.







Balanced rotary-armature design for miniaturized relay assembly resists effects of extreme shock and vibration loads. Developed by General Electric, the design employs two coils and a rotary armature. When the coils are energized, the armature is caused to rotate, compressing a helical torsion spring. In the de-energized condition, the armature floats, since it is out of engagement with the movable-contact springs and does not rest against mechanical stops; its position is controlled only by the helical spring and the shaft about which it rotates. Since spring and shaft engage the armature only at its central axis of rotation, violent shocks cannot cause the armature to rotate and disturb the normally closed contacts.

DESIGN PIRACY

By **ALBERT WOODRUFF GRAY,** Forest Hills, N. Y.

Even without a design patent, the law provides protection against copying of products by competitors—in some instances. While a copy with a mere similarity in appearance to the original may sometimes be considered illegal, in other cases an exact duplication of design may be permitted. The factors considered by the courts are given in this article, which points out the requirements for a piracy-proof design in the absence of patent protection.

RECENTLY, a controversy involving the right of an American clock manufacturer to pattern its product after the style and appearance of a clock of Swiss manufacture came before the United States Court of Appeals for a decision. This European clock was unique in the clock world. The clock was spring driven but no manual winding was necessary, this being accomplished by atmospheric changes. It was a simple open-dial model in a case with four crystal sides and crystal top, mounted on a brass base. Neither the case nor the mechanism of "Le Coultre Atmos—the perpetual motion clock," had been patented in this country.

Wide Price Differential

After the clock had been on the American market for fifteen years another clock manufacturer launched an electrically operated clock, an exact copy in design and appearance of this perpetual motion clock, at less than a quarter of its price. Representatives of the foreign manufacturer sought from the federal courts an injunction against what they asserted was unfair competition and a piracy of the design.

"The gist of unfair competition," said the court in granting this injunction, "is unlawful interference with the business of another, not merely the natural interference occasioned by lawful competition. Unlawfulness lies in fraudulently inducing the public to buy the wares of a junior competitor believing it is buying those of the senior. The essence of the wrong is thus two pronged, the public itself is misled, possibly although not necessarily to its own detriment, and the senior competitor must show at least such confusion among members of the buying public as would warrant an inference of such diversion."

However, the lower court had held in its decision, from which this appeal was taken, that confusion between these products was inconceivable considering the discrepancy in price, and that one was featured as a Swiss-made, atmospherically operated clock and the other an electrically operated clock. In setting aside this decision and ordering an injunction against further unfair competition, with an award of judgment for such damages as the representatives of the Swiss manufacturer had suffered, the appellate court said:

"Absent a design patent or secondary meaning, of course there would be no actionable harm. But the existence of a secondary meaning attached to the unique appearance of the Atmos clock is not precluded by the mere fact that more than one person distributed that clock in the same area. The actionable harm in a secondary meaning case may result either from the likelihood (a) of loss of customers or (b) loss of reputation or (c) of both. Such loss can result from the customers' belief that the competing article derives from the same source as

that of the party complaining and it matters not whether the customers know just who is the source."[1]

Lack of Producer Identity

In a denial of the existence of the secondary meaning, a few months before in an action for unfair competition in the manufacture of plastic kitchen canisters it was said by a federal court: "The test of secondary meaning is of course 'likelihood of confusion' and not actual confusion. But the confusion does not stem merely from the similarity or even identity of the questioned product with that of the first comer. It must be the confusion of manufacture, and relate to that which attaches to the personality of the manufacturer. The first maker of plastic canisters in this appealing style may have created a public desire for one of two things, (1) plastic canisters made by him alone above all other plastic canister makers or, (2) plastic canisters in a particular form regardless of who made them. The sweeping monopoly granted by the law of unfair competition extends only to the first of these conditions."[2]

This definition adopted as authority the decision of an action of this character brought in New York State against a manufacturer of adjustable wrenches.

Insufficient Producer Identity

For several years a tool manufacturer had marketed wrenches that by virtue of their appearance and novel shape had won wide-spread public approval and were known generally as the Crescent wrench. No wrench of this character had until that time been on the market.

On the web of the handle was the name of the manufacturer. Three years later a competitor began marketing a facsimile wrench but on the handle was their name. There was no imitation of the packaging, nor was the name Crescent used.

Against this manufacturer, the maker of the Crescent wrench secured an injunction forbidding marketing of the wrench, and from that decision the second manufacturer appealed. In setting the injunction aside the federal appelate court said of this essential feature of "secondary meaning" in incidents of this character: "It is an absolute condition to any relief whatever that a producer in such cases show that the appearance of his wares has in fact come to mean that some particular person—the producer may not be individually known —makes them and that the public cares who does make them, and not merely for their appearance and structure.

"It will not be enough only to show how pleasing they are because all the features of beauty or utility which commended them to the public are by hypothesis already in the public domain. The competitor has as much right to copy the nonfunctional features of the article (design, color, dress) as any others so long as tney have not become associated with the other party as the manufacturer or source. The critical question of fact at the outset always is whether the public is moved in any degree because of its source and what are the features by which it distinguishes that source."

The court supplemented this with the further comment: "In such cases neither side has an absolute right because their mutual rights conflict. Thus the manufacturer has the right not to lose his customers through false representations that those are his wares which in fact are not, but he may not monopolize any design or pattern, however trifling. The competitor on the other hand may copy the manufacturer's goods slavishly down to the minutest detail but he may not represent himself as the other producer in their sale."

In a definition of "secondary meaning" the court added: "When the appearance of the goods has in fact come to represent a given person as their source and that person is in fact the first manufacturer, it is impossible to make these rights absolute. Compromise is essential exactly as it is with the right to use the common language, in cases of 'secondary' meaning. We can only say that the courts must require such changes in appearance as will effectively distinguish the competitor's wares with the least expense to him. In no event may the first manufacturer suppress the competitor's sales altogether."

Then of restrictions on the suppression of competitive sales of this sort, the court said, "The proper meaning of the phrase 'non-functional' is only this, that in such cases the injunction is usually confined to non-functional elements since these are usually enough to distinguish the goods and are the least burdensome for this competitor to change."[3]

Established Producer Identity

Coffee mills of a characteristic shape and appearance, manufactured by one firm for over a quarter of a century, had built up an enviable reputation for the makers and had become a leading product on the market. Subsequently a competitor offered to the trade coffee mills of the same shape, design, and color. Suit was brought for an injunction against the marketing of these mills by the second manufacturer on the ground of design piracy and unfair competition. The defense by the competitor was that it had an inherent right to appropriate to its own use the designs and style of these competitive machines.

In the final disposition of that action by the federal courts a statement was made of the principle of the law that has been scrupulously followed by the courts in succeeding instances: "It is elementary law that when the simulation of well-known and distinctive features is so close, the courts will assume that the competitors intended the result they have accomplished and will find an intent to appropriate the trade of the other competitor, even though in their instructions to their own salesmen they may caution against oral misrepresentations as to the manufacture of the goods. There is evidence to

[1]References are tabulated at end of article.

show that purchasers have been deceived as to the identity of these mills but in the case of the Chinese copy such as is here offered to the public, such proof is hardly needed. No doubt with such identity in attractiveness, competition with this first manufacturer's mills would be much more effective but these competitors overlook the fact that a court will not allow a man to palm off his goods as those of another, whether his misrepresentations are made by word of mouth, or more subtly by simulating the collocation of details of appearance by which the consuming public has come to recognize the product of the first manufacturer."[4]

Included in the Federal Trade Mark Statute by a recent amendment is the essential principle that has been followed by the courts in these decisions. There it is provided in part: "Any person who shall use in connection with any goods any false description or representation, including words or other symbols tending falsely to describe or represent the same and shall cause such goods to enter into commerce shall be liable to a civil action by any person who believes that he is or is likely to be damaged by the use of any such false description or representation."[5]

The federal court said recently in applying this amendment to an incident of design piracy: "It means that the wrongful diversion of trade resulting from false description of one's products invades that interest which an honest competitor has in fair business dealings—an interest which the courts should and will protect whether it be called that of 'property', 'quasi-property' or something else. It represents within this area an affirmative code of business ethics whose standards can be maintained by anyone who is or may be damaged by a violation of this segment of the code. In fact it says, you may not conduct your business in a way that unnecessarily or unfairly interferes with or injures that of another. You may not destroy the basis of genuine competition by destroying the buyer's opportunity to judge fairly between rival commodities by inducing such factors as falsely descriptive trade marks which are capable of misinforming as to the true qualities of the competitive products."[6]

Widely Advertised Identification

Another distinction is made by the courts between the means implemented to deception of this character. The law is aimed at the end to which such misrepresentations, irrespective of whether they are design, dress, color, or words, are directed. Self-locking nuts designated as "elastic stop nuts," and marketed by one manufacturer, had an insert of red fiber and were advertised as "nuts with the red color."

Self-locking nuts of the same type were later marketed by a competitor, identical in color and appearance to those of the first manufacturer's product under the same trade name of elastic stop nuts. In ordering an injunction in the suit brought by the first manufacturer the federal court said of this piracy: "The test should be whether the public is likely to be deceived. The good will of this manufacturer which it had built up at great expense over a period of years would be whittled away. Courts ought not to be so feeble as to be unable to prevent this. In the case now before us we have proof of the good will built up by this manufacturer over a period of many years and of the general acceptance by the trade of the style, dress, name, and appearance of its product as indicating it to be this manufacturer's product. These valuable assets of this manufacturer are without right suddenly pre-empted by its competitor in its copying of the style, dress, and nomenclature of the first manufacturer in the marketing of a new product."[7]

Exact Copy of Design and Trademark

At Waltham, Mass., a watch manufacturer adopted the name "Waltham" in its advertising and on its watches in an attempt to ride on the good will of the manufacturer of the widely known Waltham watches, who applied for an injunction. It was contended by this competing manufacturer that it had a right to use in its advertising the name of its address as it had done. The decision granting the injunction was rendered on the opinion of Justice Holmes, later a member on the United States Supreme Court.

"It is true," he said here, "that a man cannot appropriate a geographical name, but neither can he a color or any part of the English language or even a proper name to the exclusion of others whose names are like his. Yet color in connection with sufficiently complex combination of other things may be recognized as saying so substantially that the competitor's goods are the first manufacturer's as to pass the injunction line. So although the first manufacturer has no copyright on the dictionary or any part of it he may exclude a competitor from a part of the free field of the English language, even from the mere use of generic words, unqualified and unexplained, when they would mislead the other manufacturer's customers to another shop. Whatever might have been the doubts some years ago we think that it is now pretty well settled that this manufacturer merely on the strength of having been the first in the field, may put later comers to the trouble of taking such reasonable precautions as are commercially practicable to prevent other lawful names and advertisements from deceitfully diverting this manufacturer's custom."[8]

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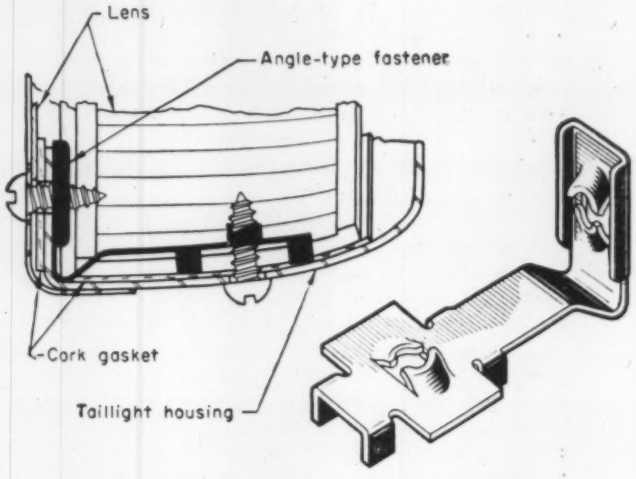
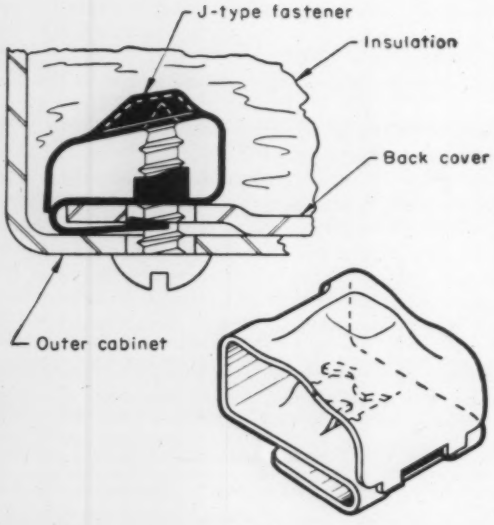
Multiple-Function Fasteners

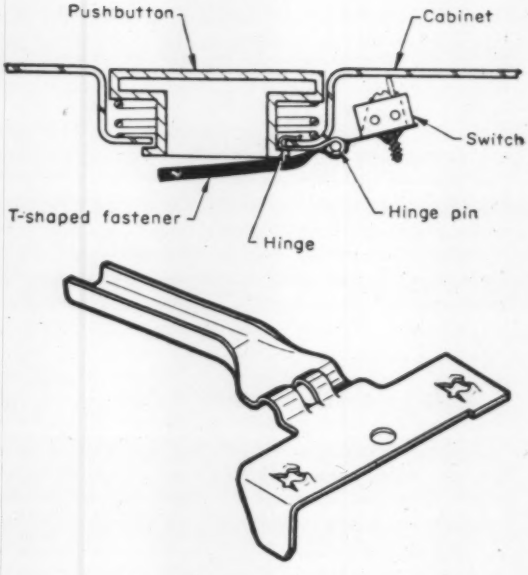
Although different in details of design and application, fasteners shown in the accompanying illustrations have one characteristic in common. All were developed to perform one or more functions in addition to that of fastening. Range of design possibilities includes auxiliary service as a bracket, spacer, insulating surface, hinge, spring, or friction brake. Manufactured by Tinnerman Products Inc., all of these fasteners are heat-treated spring steel and incorporate some form of spring-action locking or retaining device, eliminating the need for nuts, lockwashers or other secondary fastening elements. In addition, the "multiple-function" construction concept reduces the number of parts required for assembly, streamlining production operations and simplifying design specifications.



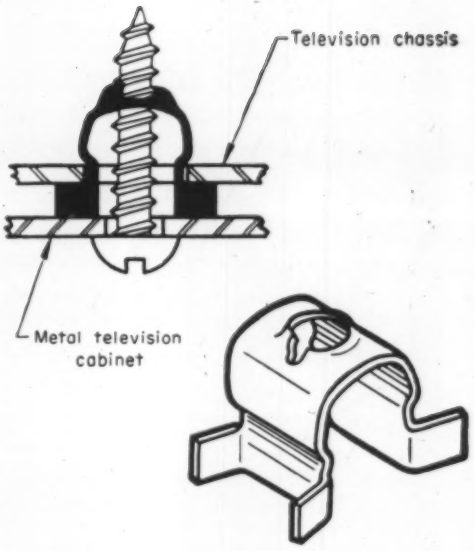
Multiple-function, angle-type fastener holds curved glass lens to inside of automotive taillight assembly and secures the outside chrome retaining ring. This design eliminates four separate angle brackets plus four drilling and tapping operations that were previously required per application.



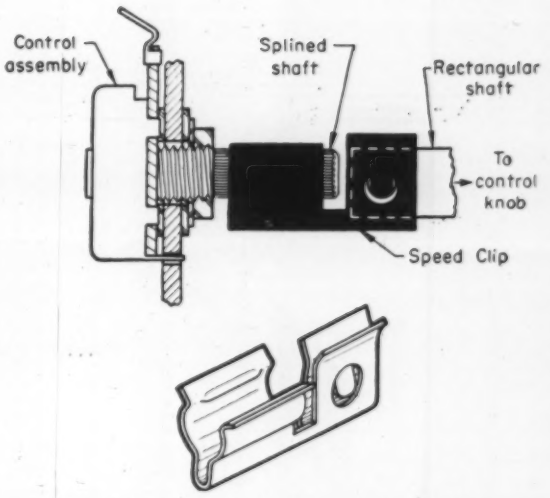
Hooded, J-type fastener is used to assemble refrigerator cabinet panels. Providing one-piece, self-locking attachment, fastener incorporates special hooded construction which keeps insulation from binding screw. It also prevents sharp screw points from chafing insulation and protects assemblers from possible scratches from screws when working in confined areas.



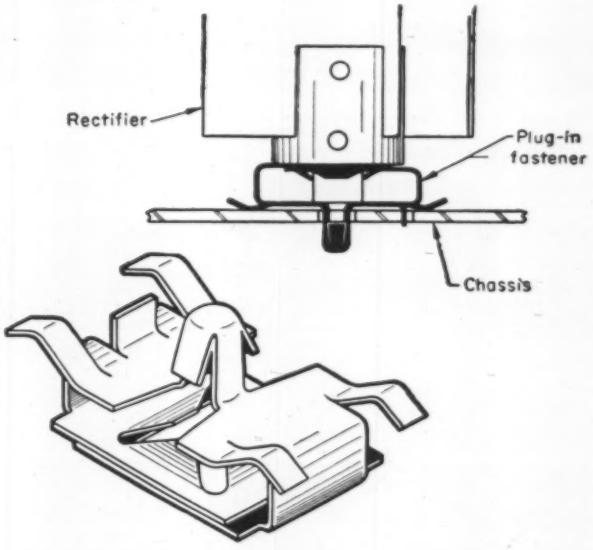
T-shaped fastener design serves as a miniature snap-action switch mount on home laundry equipment. It provides base surface and locking attachment for switch unit, plus pivoting hinge to reverse direction of initial force. It also furnishes long arm and surface for operating pushbutton. Switch cuts off power when excessive vibration occurs in washing machine.



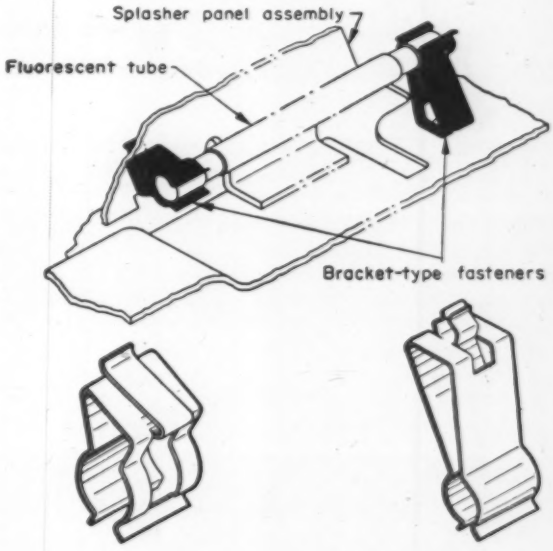
Combination fastener and spacer replaces plastic fastener in conversion from hot to cold chassis on portable television sets. Fastener serves as spacer between chassis and frame, secures chassis to frame, and acts as electrical ground connection.



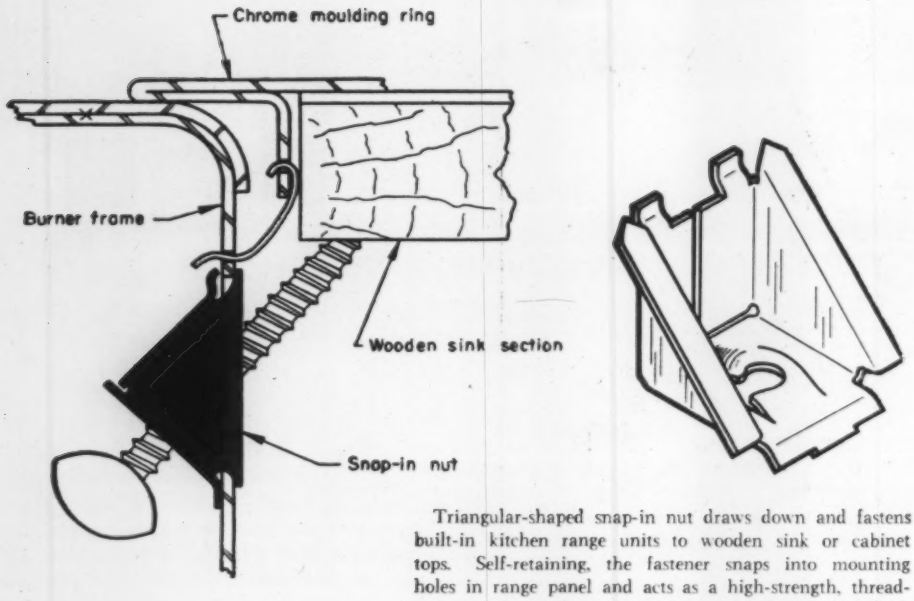
Speed clip was developed to connect potentiometer shaft to control shaft on television set. Splined potentiometer shaft is held under spring tension by dimpled section of fastener. Overtorquing causes fastener to slip on splined shaft, preventing damage to control assembly. Special locking tab in U-shaped portion of fastener secures it firmly to control shaft. Design permits use of a stamping or inexpensive stock for the control shaft.



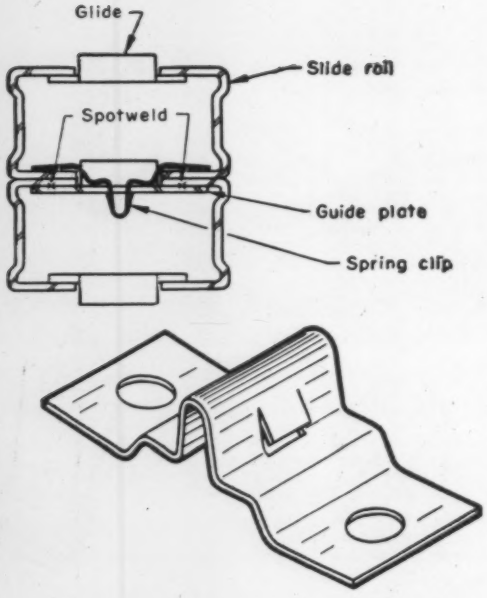
Plug-in fastener facilitates mounting of germanium rectifiers in electronic equipment. Eliminating auxiliary fastening devices, fastener incorporates a special push-on impression which is merely slipped down over square plastic stud on rectifier. Entire assembly can then be snapped into mounting holes in chassis and is held in place by special dart-shaped extensions on fastener. Four spring legs bear against chassis panel, holding assembly firmly in upright position while at the same time providing a resilient cushion to protect rectifier against shock and vibration. Locating tab on fastener prevents assembly from turning in mounting hole.



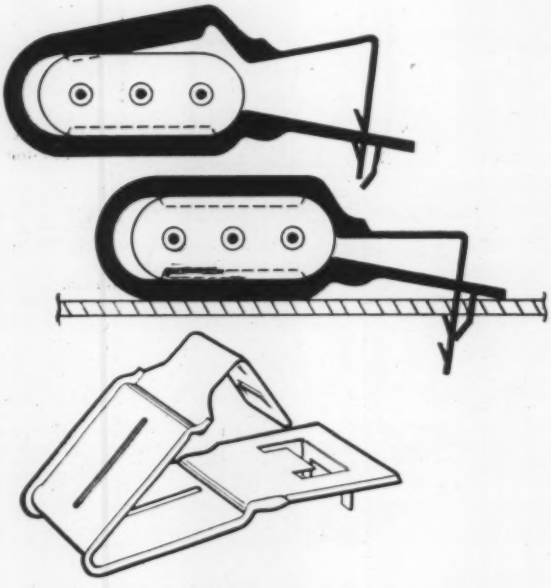
Bracket-type fasteners are used in combination to provide simplified mounting of fluorescent lighting tube on washer-dryer unit. Both are merely snapped into mounting holes in panel; one employs dart-shaped retention prongs, the other utilizes U-shaped leg which clips over panel for self-retention. Once the fasteners are installed in tube-receiving position, lighting tube is snapped into place where it is held firmly under spring action. Dual fastener assembly replaces six separate parts formerly used.



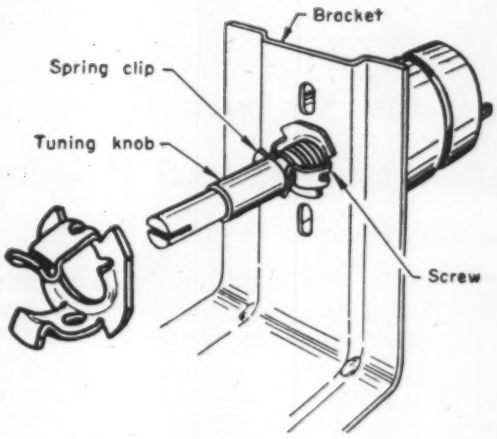
Triangular-shaped snap-in nut draws down and fastens built-in kitchen range units to wooden sink or cabinet tops. Self-retaining, the fastener snaps into mounting holes in range panel and acts as a high-strength, thread-engaging insert for tensioning screw. It provides high torque capacity so range unit can be drawn tightly to cabinet top, preventing seepage of fluid around edges.



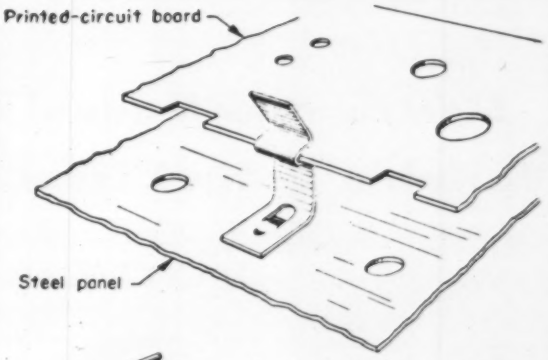
Spring clip was designed to join metal slide rails on expandable table tops. It snaps into elongated slot in metal guide plate which is spot-welded to inner face of one slide rail. Spring arms bear against inner flange of companion rail, holding both rails together firmly yet permitting them to slide easily. Holes in each arm of fastener engage protrusions in inner rail flange that serve as stops. The fastener eliminates separate spring-tensioning devices, and simplifies assembly and production requirements.



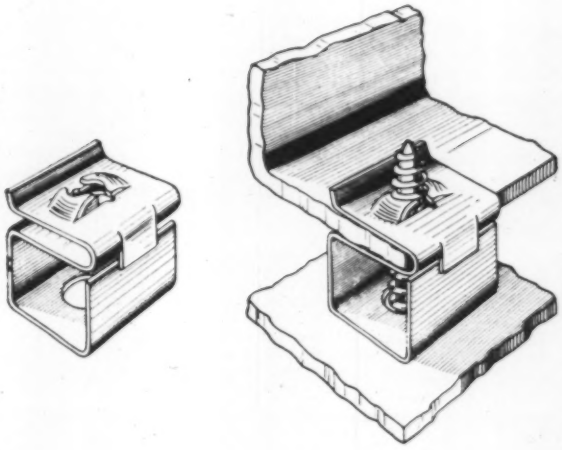
Wire-harness clip accommodates any of the popular one, two or three-wire cord sizes for electrical appliance wiring. Fastener is slipped over wire and compressed to first locking position. Locking tabs on the underside of the fastener locate and center the latching leg over the hole in the panel. On compression to the second and final locking position the latching leg is forced rearward by the locking tabs to catch the underside of the panel, thus securing the wire in the clip and the clip to the panel.



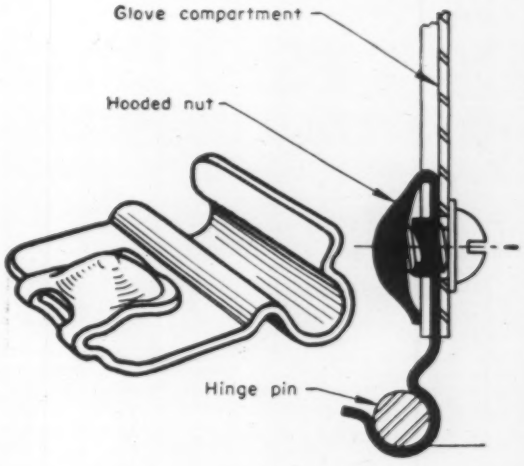
Multiple-function spring clip for a dual-control television tuning-switch assembly retains switch to chassis or bracket and, also, provides constant spring tension for both push-pull and revolving controls. Switch is mounted in hole in bracket or panel, and fastener is screwed down threaded shaft to a locked position, firmly retaining switch. Once the fastener is tightened, spring fingers bear down on the shaft of the switch and provide tension to keep tuner in alignment and push-pull control in proper setting.



Latch-type fastener for securing printed circuit boards to radio chassis is snapped into mounting hole in chassis where lip-and-catch feature holds it securely in position. Circuit board is then snapped into recessed portion on upper leg of fastener and is held at prescribed height under spring tension. Extension on fastener provides an easy lead for insertion of circuit board and simplifies fastener removal for servicing unit.

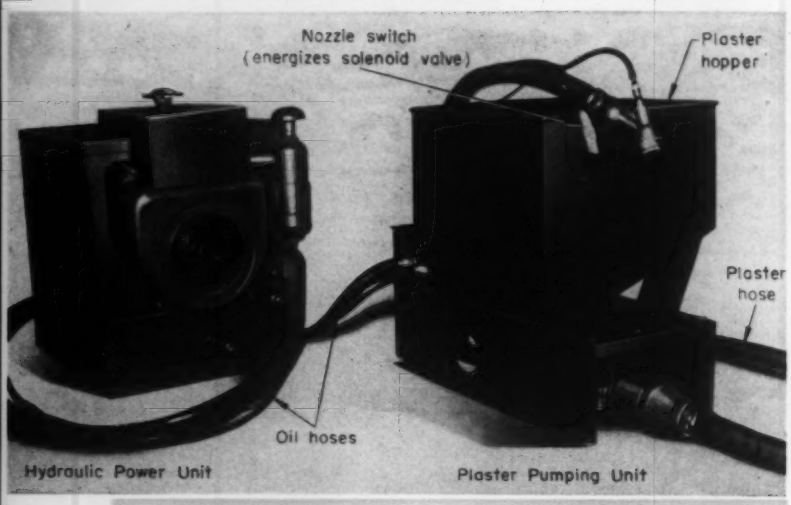


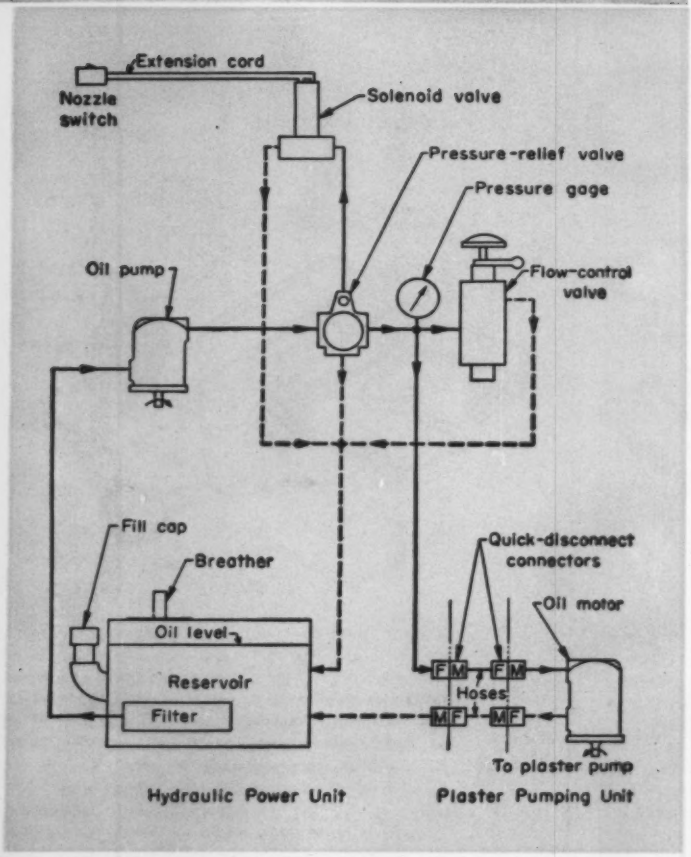
U-type fastener doubles as a spacer on television focusing unit. Upper U portion of fastener is pressed over panel. Then the focusing tab is placed on the lower formed "box," the clearance holes are aligned, and the screw is driven. Sheared finger on U bend of fastener prevents nut from collapsing when torque is applied.



Hooded-nut design is used as hinge for glove compartment door in automotive application. Hinge pin is retained within the compartment by a pair of these special fasteners. Two more are attached to the door in position to be snapped onto the secured hinge pin, completing a strong and secure assembly. Special cap over the screw impression protects against sharp edges of screw.

Electric and Manual Bypass Valves Give Variable Output from Constant-Speed Pump





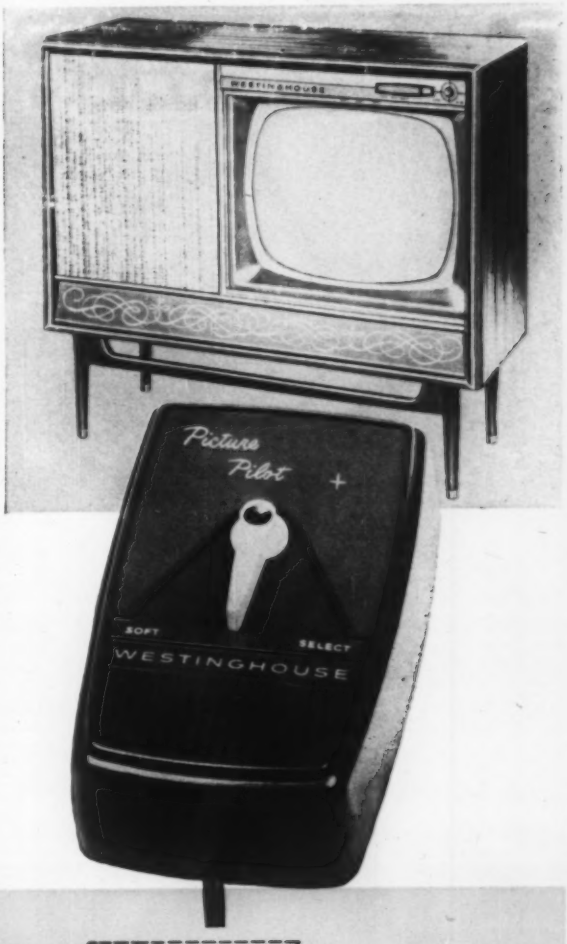
HIGH-PRESSURE HYDRAULIC power source for a new mobile plastering machine can be located as far as 100 ft away from the plaster pumping unit. As reported by J. Kinzelman, consulting engineer, Plastering Development Center Inc., Chicago, the machine is made in two units linked together hydraulically. One unit, the Power Pak, consists of a four-cylinder gasoline engine, air compressor, a Denison pump, pressure-relief valve, flow-control valve, and solenoid valve. The other unit, the Pump Pak, is made up of a Denison fluid motor, speed reducer, pump, and plaster hopper.

At the pumping unit, plaster is pumped through 60 ft of hose. At full output, this variable-speed machine sprays on a ½-in. layer of plaster at the rate of 250 sq yd per hr

REMOTE OPERATION of the engine-driven hydraulic power unit permits operator to turn plaster pump "on" or "off" at will. By means of an electric switch on an extension cord, the operator can energize a solenoid valve in the Power Pak. When this valve is closed, main flow of oil goes directly through the pressure-relief valve and 100 ft long hoses to the fluid motor, thus operating the plaster pump. When the solenoid valve is open, main flow of oil is diverted back to the reservoir. To decrease the speed of the plaster pump, the manual flow-control valve is opened, allowing part of the oil to bypass the motor and flow back to the reservoir in hydraulic power unit

Signals through House Wiring Used To Control TV Set

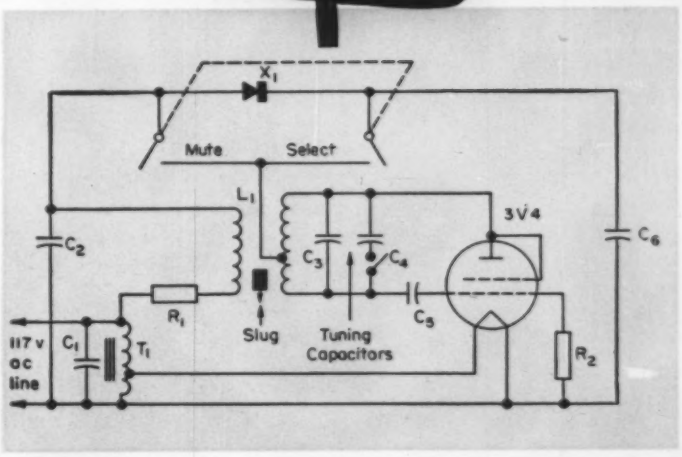
REMOTE CONTROL of television receivers is provided in a new electronic signaling device. Developed at Westinghouse Electric, the control unit uses carrier current



RADIO-FREQUENCY SIGNALS generated by a small transmitter at the viewer's finger tips are carried over the house electrical wiring system to control the television receiver. These signals actuate relays in the receiver that control channel selection and sound muting. The control system is particularly suited for use with receivers equipped with power tuning and electronic automatic fine tuning.

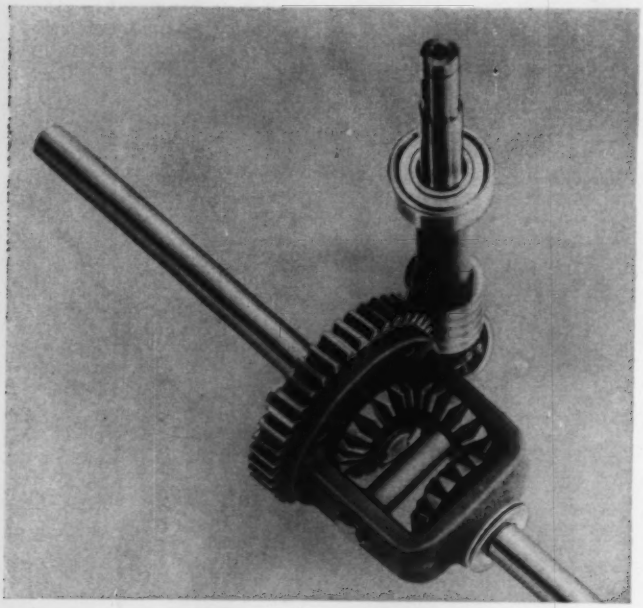
Control system functions—channel selection and sound muting—are accomplished with two types of carrier signals. A continuous wave of the required duration activates both the channel-selecting relay and the sound-muting relay so that the television receiver can be tuned through program channels without sound blasting. Picture muting is also provided to prevent annoying flashes. A modulated wave activates only the sound-muting relay. Four alternate carrier frequencies, in the 50 to 75 kc range, have been chosen so that a random distribution of carrier frequencies can be obtained to prevent interference between systems if several are in close proximity.

When the two-position control switch is moved to the "select" position, dc voltage is applied to the oscillator plate circuit and the continuous wave signal is produced; when the switch is in the "mute" position, 60-cycle voltage is applied to the oscillator and the modulated carrier signal results. The switch will latch in the "mute" position to provide continuous muting

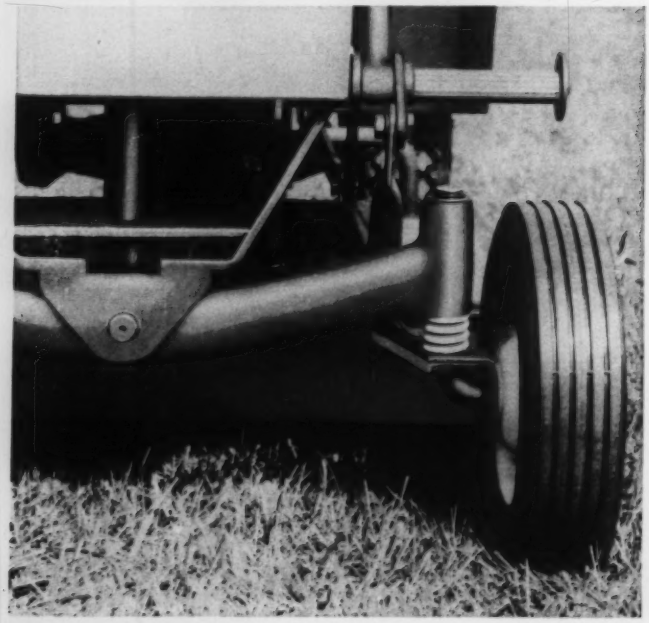


Automotive Type Differential and

RIDE-IT-YOURSELF lawn mower is built by Porter-Cable with many automotive type features. One of the design objectives of the Mark XXVI was to overcome the problem of "scalping" high spots on lawns. This is accomplished by means of a new floating pan that houses the rotary cutting blade. The pan is guided on two small rubber-tired wheels which follow an irregular terrain

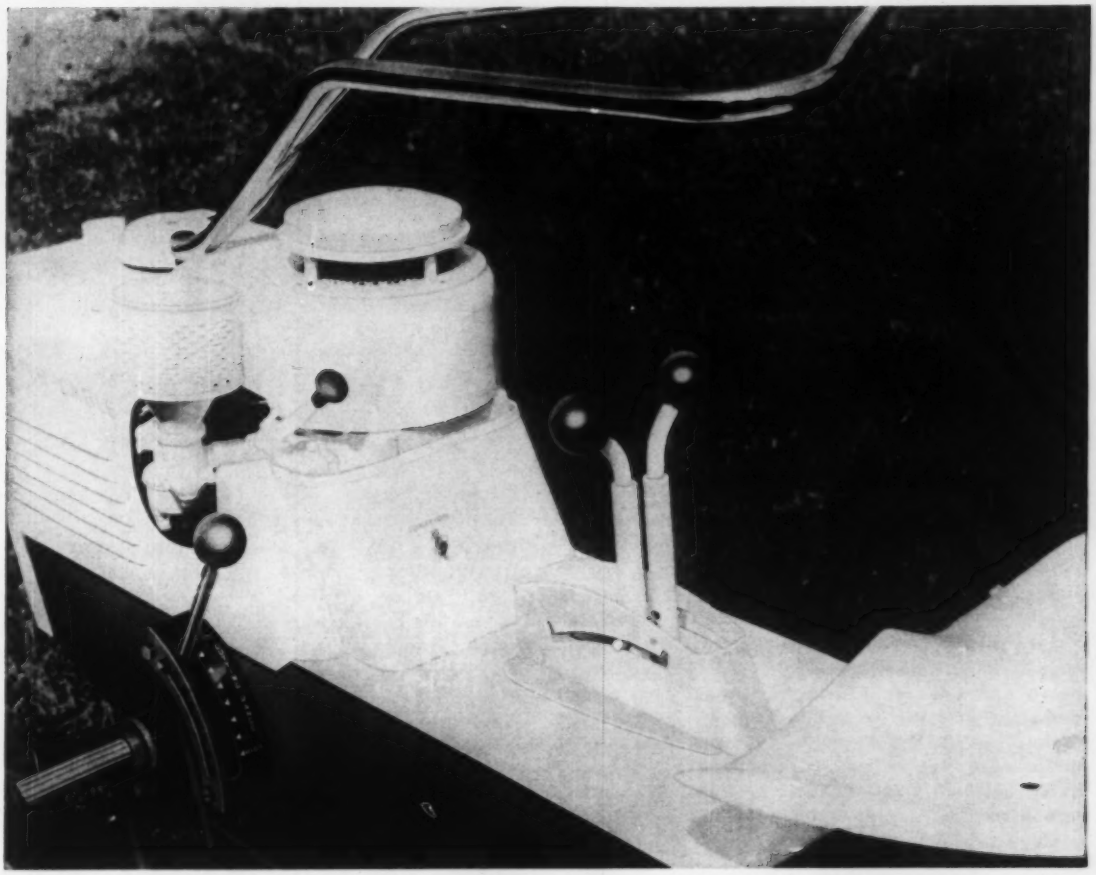


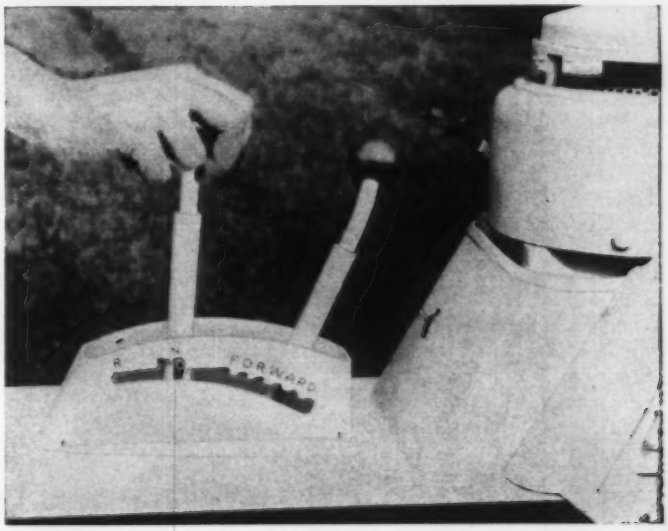
AUTOMOTIVE TYPE DIFFERENTIAL in mower applies equal power to both rear wheels and prevents gouging the lawn. A cast-iron axle housing maintains precision alignment of worm and bevel gears



COIL SUSPENSION on front wheels plus fully pneumatic tires assure cushioned riding comfort. For stability on steep slopes, the yard vehicle is designed with a low center of gravity and a long wheel base

Coil Springs Applied in Lawn Mower





AIRPLANE-STYLE GROUPED CONTROLS include the gearshift, ignition switch, throttle, choke, blade engagement lever, automatic brake, fuel shut-off valve, recoil starter, and cutting height lever.

The cut selector makes it possible to adjust height of cut in 1/4-in. increments from 1 1/2 in. to 3 1/2 in. The entire cutting assembly can be completely removed to use the vehicle for other purposes.

The gearshift provides five forward speeds plus neutral and reverse. Mower automatically brakes to a stop when shifted to neutral

Designer's Guide for

By **W. E. EBELING** and **A. J. CHENEY**
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THERMOPLASTICS, such as polyethylene, acetal, acrylic, and nylon resins, may be joined by spin-welding. The technique uses frictional heat, generated by rotational rubbing of two contacting surfaces, to produce joints with the same quality as the parent material. Specifically, the spin-welding process involves rotating one section, to be welded against another which is held stationary. Speed and pressure generate frictional heat which melts the adjacent surfaces. When sufficient melt is obtained, pressure is increased to squeeze out all bubbles and to disperse the melt uniformly between the weld faces. The stationary section is then released, or the rotating section stopped, to halt the rubbing action and allow the weld to form. Pressure is maintained until the weld sets.

In addition to the outstanding quality of the welds produced, spin-welding offers economic advantages through speed and simplicity of operation. Standard machine-shop equipment, such as lathes and drill presses, Fig. 1, may be adapted for most spin-welding jobs. With the aid of jigs and fixtures, standard equipment may be converted to high-production units.

Spin-welding is especially useful for welding thermoplastics which may oxidize at high temperatures. Since the welding surfaces remain in contact throughout the process, air is excluded from the joint and oxidation of the melt is prevented. No solvents, cements or other foreign elements are required in the operation, so the finished joint is of similar quality to the virgin material.

Frictional heat generated by spin-welding is of such intensity that it produces almost immediate surface melting while temperature of the material immediately beneath the surface remains relatively unchanged. This condition is helped by the good insulating capacity of most plastics. For many applications no surface preparation is necessary. A rough saw finish can be welded into a joint of similar quality to that obtained from a machined surface.

One disadvantage of this technique is in the limitations on joint design. The required circular shape may, however, be designed into a noncircular part. A possible second disadvantage is flashing which is sometimes necessary to insure complete welding. However, joint design may be regulated to minimize this flash or to trap it in integral part recesses. Otherwise, flashes may be easily trimmed during the spin-welding operation.

Applications: Spin-welding may be applied to almost any assembly operation involving a thermoplastic with a circular joint. The following are only a few examples:

HOLLOW MEMBERS: Aerosol bottles, plastic-pipe sections, and similar hollow members, are ideally suited for assembly by spin-welding, Fig. 2. Multicolored bottles may be produced by spin-welding injection-molded sections. Bottoms, end caps, and valve mechanisms may also be assembled by spin-welding. Because of the thin wall sections used in most aerosols, tapered or tongue-and-groove joints should be used to insure proper alignment and to increase the weld area. Spin-welding may be added to a production line, substituting for the conventional crimp-capping operation.

SHEET WORK: Discs may be welded into plastic sheet for repair work or to produce interesting multicolor effects. A plug with 45-deg tapered edges and about 1/32-in. diametral interference is most successful, Fig. 3.

FILLED CONTAINERS: Liquids may be sealed into

SPIN-WELDING

a new joining technique for thermoplastics

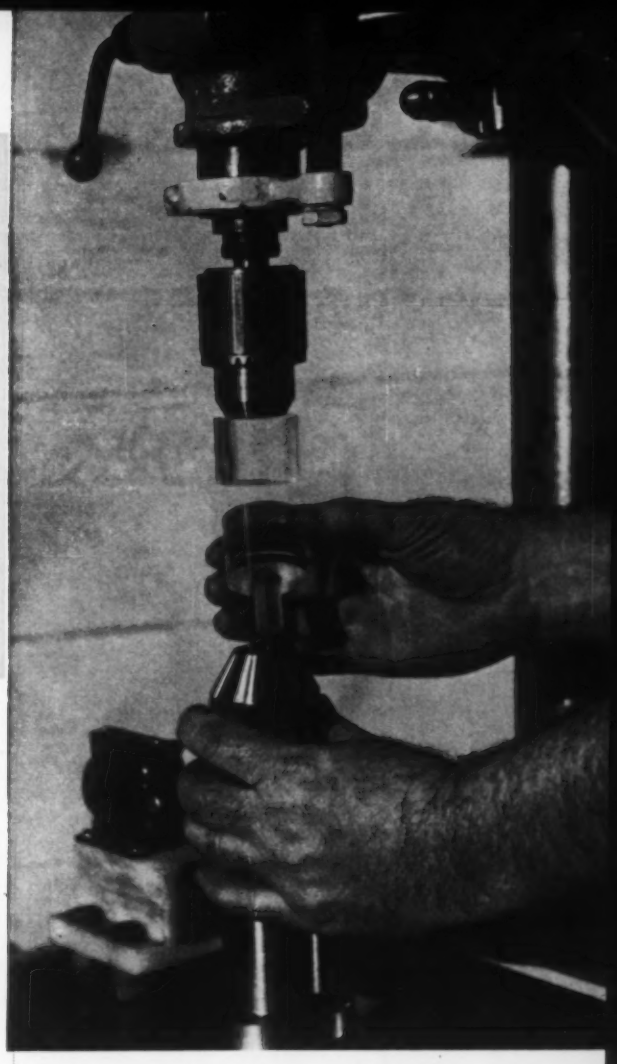


Fig. 1 — Standard equipment such as an air-feed-equipped drill press is adequate for spin-welding

thermoplastic containers by this technique. Surface heating is so intense that welding may be performed beneath the surface of a liquid. Liquid-filled containers, completely free of bubbles, can thus be simply and economically produced. This technique was used to assemble floating compasses during World War II.

GENERAL FASTENING: Spin-welding may also be used as a substitute for riveting or mechanical fastening, Fig. 4. Flanged rods may be spun in to hold ball-bearing races, gears, or other rotating members, Fig. 5. Techniques used in spin-doweling, described later, are used.

Joint Design: Joint geometry is the most important factor influencing weld quality and should, therefore, be carefully determined. Joints should provide maximum weld area while minimizing surface-velocity differential due to different diameters. Weld area may be increased by using step, tongue-and-groove, or tapered joints, Fig. 6, 7, 8, and 9. The limitation on weld area is usually either wall thickness or rotational drag created by increased surface area.

Velocity differential with solid parts is minimized by removing the centermost section of the weld area (where surface velocity approaches zero). Weld strength may actually be improved in small sections, even if the weld area is not increased to compensate for the center removal. Velocity differential may also be compensated for by crowning the central area so that it melts and disperses first, Fig. 10.

Alignment between sections is improved by use of tapered or tongue-and-groove joints. These joints also reduce wobble—critical in thin-walled sections such as aerosol bottles.

If two compositions of a single material have

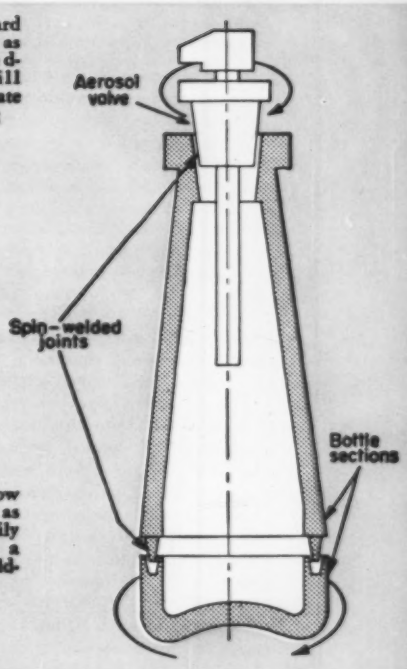


Fig. 2 — Hollow members, such as bottles, are readily assembled into a unit by spin-welding

slightly dissimilar melt points, such as Alathon 10 and 14 polyethylene resins, flash produced in welding them may be directed internally or externally. A tapered joint on a hollow cylinder will usually flash externally, with no flash on internal surfaces, if the male section is the higher-melting material.

Weldability: As yet, no true thermoplastic has been tested which could not be spin-welded. Resultant weld strengths, however, differ widely among the various plastic materials. The weld strength of a single material, in fact, may vary with its particular application.

Table 1—Typical Weld Strengths (per cent of base material)

Material		Material								
		—Alathon—			Lucite		—Zytel—			Delrin
		10	25	37	140	130	101	105	31	500X
Alathon (Polyethylene)										
	10	95	80	85	..	..	..	..	..	..
	25	80	90	70	..	..	..	..	..	..
	37	85	70	95	..	..	..	..	..	..
Lucite (Acrylic)										
	140	..	..	..	85	75	..	..	..	30
	130	..	..	..	75	85	..	..	..	35
Zytel (Nylon)										
	101	..	..	..	..	..	70	60	55	25
	105	..	..	..	..	..	60	60	50	25
	31	..	..	..	..	..	55	50	70	30
Delrin (Acetal)										
	500X	..	..	..	30	35	25	25	30	60

Where no values are given, weld strength is negligible (below 10 per cent).

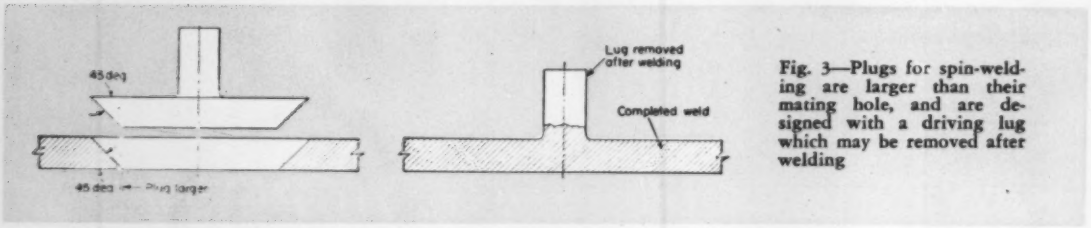


Fig. 3—Plugs for spin-welding are larger than their mating hole, and are designed with a driving lug which may be removed after welding

Want to try spin-welding?

Although spin-welding is not a new development, it is not widely known and has been used in the past by only a few widely separated firms. For those who would like to experiment with the process, most of the known operating variables are given below. It should be noted that the success of spin-welding depends upon finding the proper combination of materials, speed, cycle time, and pressure for each individual application. Considerable experimentation may be required to achieve optimum results, but once the proper values for the operating variables are established, the process is fast, inexpensive, and simple to operate.

Heat generated between two rotating, rubbing surfaces is a function of the relative surface velocity, contact pressure, and duration of contact. Other factors are material properties, like coefficient of friction and heat-transfer capacity. Experimental data indicate a direct linear relationship between velocity and pressure, so that an equal heating effect is obtained by doubling either speed or pressure while the other variables are held constant. This relationship provides easy conversion from one piece of equipment to another and, in some cases, from one spin-welding application to another.

PRESSURE: Applied uniformly to the surface to be welded, pressure must be great enough to force any bubbles, contamination, or degraded material from the joint. In many applications, best results are obtained with an increase in pressure after initial melting. Material is thus squeezed between the joint faces as the weld sets up. More pressure is required at higher temperatures to prevent degrading or bubbling of the thermoplastic material in the joint itself.

SURFACE VELOCITY: For the flat end of a rotating cylinder, the effective surface velocity is 2/3 the circumferential velocity—a function of both diameter and rotating speed. Average point velocity on an annular surface is

$$V = \frac{2\omega}{3}\left(\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}\right)$$

where V = average point velocity, in./sec; ω = angular velocity, rad per sec; r_o = outside radius, in.; and r_i = inside radius, in.

CYCLE TIME: The welding time should be only long enough to insure complete welding. A short cycle minimizes flash and internal stresses. In many applications, one or two seconds are sufficient. Total production-cycle time, including loading and removing parts, is greatly influenced by effectiveness of the holding devices. With a few trial runs an operator can usually determine what time, speed, and pressure are required to provide the best weld for a particular application. Automatic machine settings can thus be determined from manual, experimental runs.

The approximate ranges of the variables that have produced satisfactory welds are given in the table. Values given are to be used only as starting points for experimentation. The shortest cycle that will provide adequate welding should be determined. Pressure and speed should be chosen within the limits of control accuracy, but in all cases must be sufficient to pro-

Suggested Ranges of Operating Variables

Material	Average Point Velocity (ft/sec)	Initial Pressure[1] (psi)
Zytel 101 (Nylon)[2]	15 to 50	25 to 150
Delrin 500X (Acetal)	15 to 35	25 to 150
Lucite 140 (Acrylic)[3]	10 to 35	15 to 125
Alathon 10 (Polyethylene)[4]	5 to 60	10 to 100

1. In some applications, a secondary high pressure, or squeezing, after initial melting has proven beneficial in improving weld quality. This secondary pressure may be many times greater than that used to obtain initial melting, and is generally limited only by material stiffness and strength.
2. Data also apply to Zytel 105, 42, and 31.
3. Data applicable to most extruded or molded acrylics.
4. Data also apply to Alathon 14 and 25.

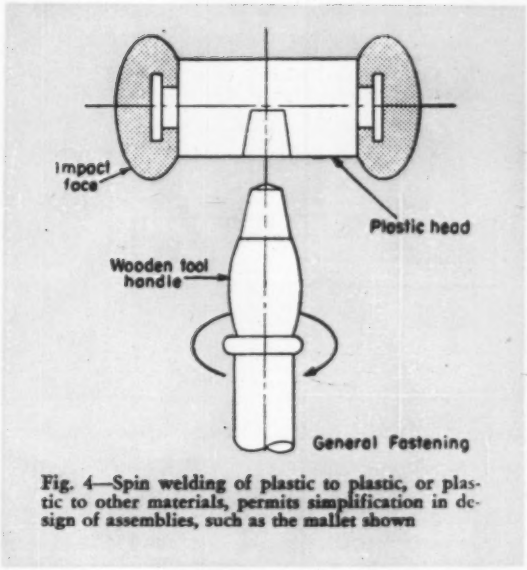


Fig. 4—Spin welding of plastic to plastic, or plastic to other materials, permits simplification in design of assemblies, such as the mallet shown

Residual stresses and heating patterns greatly affect weld strength. However, with close control of the welding operation and with proper material conditioning, welds of constant quality may be predicted and maintained. Approximate range of weld strengths obtained with good welding techniques on the Du Pont plastics is given in Table I. These values should be used with discretion and a standard safety factor included when they are applied to joint design.

Thermoplastics with the highest degree of polymerization appear to be best for spin-welding. Residual monomer (unpolymerized material), present in many plastics, is generally unstable at elevated temperatures and tends to gas-off in the welding operation. The resultant bubbling effect is difficult to control and greatly reduces strength and clarity of the finished welds. This characteristic is quite evident in the acrylics. Molded and extruded acrylic sections, which generally have less residual monomer than do cast acrylics, produce the best welds and duce melting rather than grinding of the welding surfaces.

CYCLE CONTROL: The welding cycle may be controlled by any of several variables: drag, time, or axial spindle position. Of these, time and position are most widely used. Position regulation, which insures that a given amount of material is melted and displaced at each cycle, may be governed by a limit switch or stop. The limit switch is normally used with an automatic feed unit and an automatically disengaging adaptor, similar to the one shown. Accurate part positioning is essential for consistent results with position regulation.

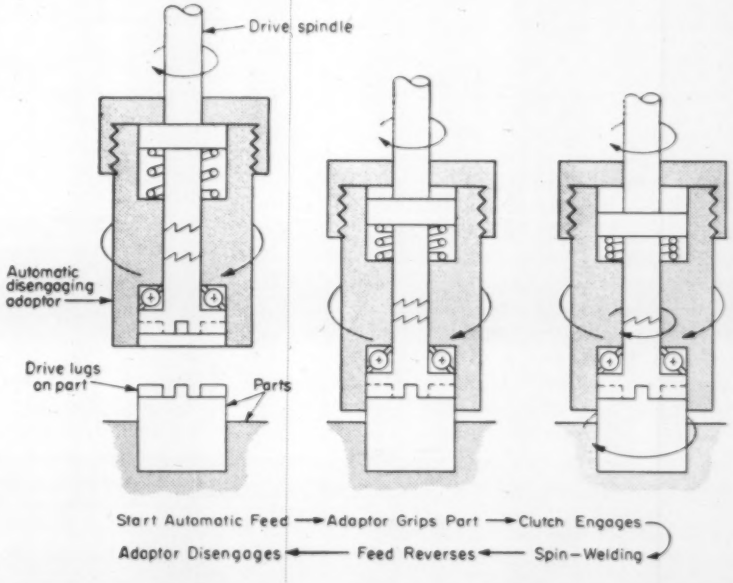
Time control, which depends on reproducible heating rates, is also best utilized with an automatically disengaging adaptor. When production volume does not merit an automatic setup, visual control may be sufficient and the rubbing may be stopped simply by shutting off the spindle drive.

Pressure control is best obtained by use of an air feed unit. Automatic feed units are available for most drill presses. Some feed units provide a given rate of feed, while others, air-operated, provide a constant pressure. Where close control is required, the air feed unit is preferable. Standard drill-press and lathe speeds are practical for most spin-welding operations. However, surface velocity increases with increasing diameter and slower rotational speeds are sometimes required. Slow-speed attachments are available for standard equipment and are easily adapted to the required application.

WORK-HOLDING DEVICES: The function of fixtures in spin-welding is to position and support the surfaces to be welded. It is therefore essential that the fixtures be precisely and durably constructed. Alignment is especially important, since any offset or wobble will be transferred to the weld area and cause uneven melting. Joints may be designed which will compensate for slight misalignment and wobble, but precision fixtures are required for welding at maximum speeds.

Many parts have sufficient surface to be gripped simply by pressing into a matched housing or by holding in a chuck. Others require mating lugs and recesses or a more complicated connection. In designing parts for production welding, the gripping mechanism should be considered carefully. Lugs, where required, may be molded as part of the sections to be welded.

The portion of the fixture which actually supports the weld area should be as close to it as possible for maximum rigidity and control.



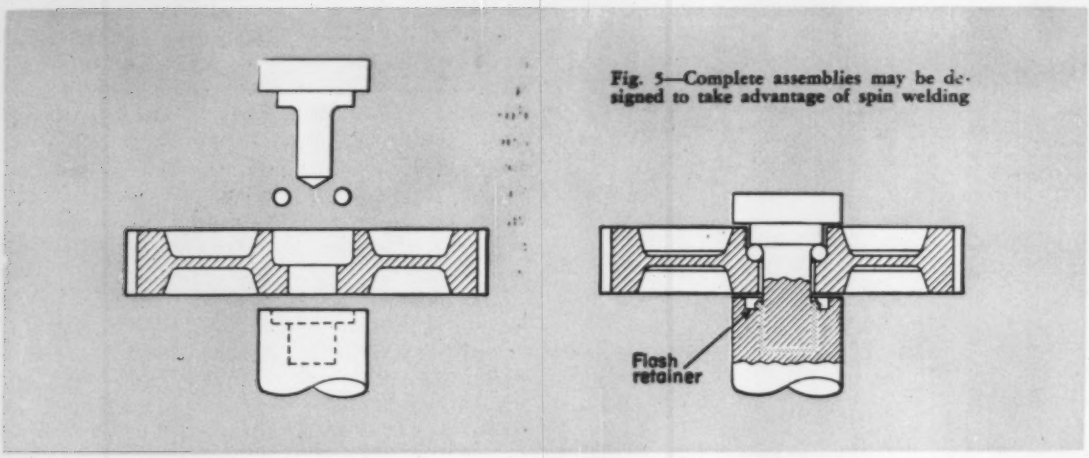


Fig. 5—Complete assemblies may be designed to take advantage of spin welding

require less control during the welding operation.

Joint Strength: Weld quality depends upon several contributing factors. Environmental variation prior to welding and prior to testing may greatly influence actual and apparent weld strengths because the moisture content and temperature affect the parent-material strength. Specifying weld strength as a percentage of parent-material strength under given conditions is, therefore, most desirable. Moisture content prior to welding has been found to be a critical factor in obtaining maximum weld strength. Dried nylon, for example, run under similar conditions, has resulted in welds five to ten times stronger than those of wet nylon. (Nylon will absorb moisture under normal conditions—2.5 per cent at 73 F and 50 per cent relative humidity—and may be saturated, by boiling, to 8.5 per cent moisture by weight.)

Time may also affect weld strength. Internal stresses are at their highest level immediately after welding and will gradually decrease by cold flow with time. Annealing after welding (as is sometimes done after molding a complicated shape) is often beneficial.

Reorientation of the molecular structure after welding is also a function of time. This causes the weld strength of some thermoplastics to increase until it reaches a maximum several hours after welding. Polyethylene, for example, reaches its maximum strength after about 10 hours.

Residual Stresses: Because surface velocity varies across the face of a rotating disc, the heating pattern across the weld area of a spin-weld section will also vary. The resulting trapped internal stresses are maximum at the center of the weld and minimum at the outer surface. Usually, therefore, these stresses have little effect on the surface-craze resistance or surface-weathering qualities of a spin-welded part. However, if the more highly stressed areas of the weld are exposed to a crazing agent, violent stress crazing will result. Annealing of highly stressed joints is consequently desirable.

Internal stresses also affect the tensile and impact properties of a welded part. In some cases,

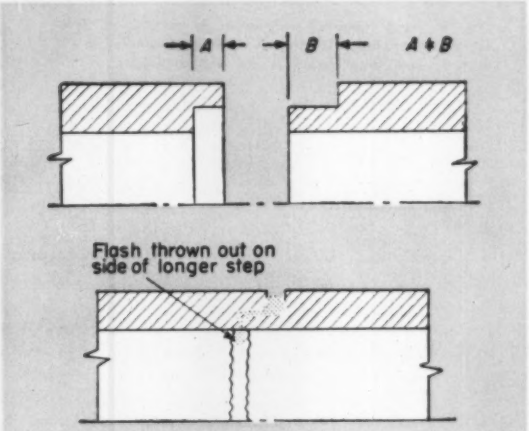


Fig. 6—Step joints should be a slip fit and may be designed to direct the flash in either direction

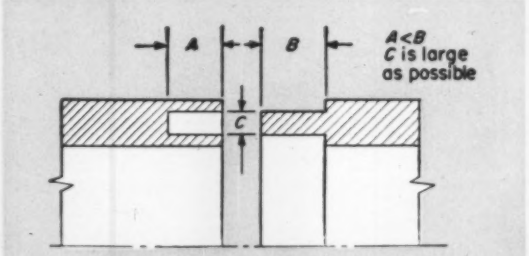


Fig. 7—For tongue-and-groove joints, tongue should be longer than mating groove and as thick as possible. Joint is a slip fit before welding.

they will act as points of stress concentration, while in others they may actually increase the strength of the part in a given direction. Whenever possible, actual use-testing of sample parts will provide the surest answer as to the suitability of spin-welding for a particular application.

Flash Control: Because molten plastic is a viscous fluid, pressure applied to it is transferred equally in

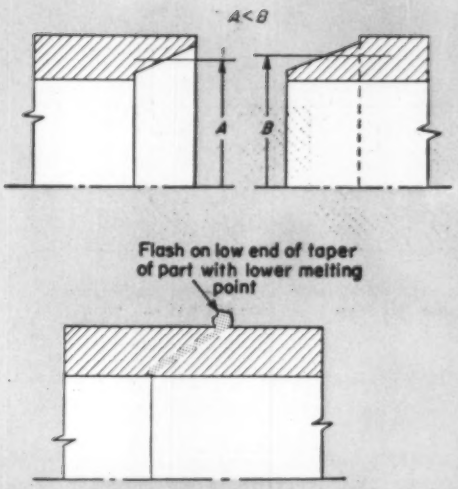


Fig. 8—Matched-taper joint has larger pitch-line radius on male section. Flash direction is accomplished by selecting parts with different melting points.

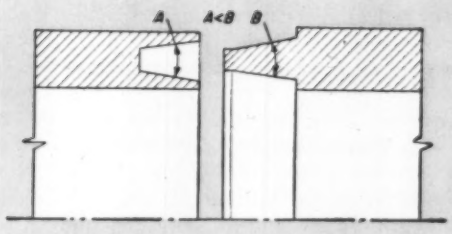


Fig. 9—Taper-groove joint is designed with larger included angle on tongue, which is thick as possible and has a short, straight extension

all directions. Thus, welding pressure causes the melt to move in all directions from its point of origin and the excess melt is forced out from between the mating surfaces in the form of flashing. When the spin-welding cycle is not automatically controlled, flashing may be the best indication of complete welding; however, excessive flashing is generally undesirable and can be controlled by careful regulation of its contributing factors in production.

One such factor is proper joint alignment, which depends upon control of joint tolerances, accuracy in positioning the sections in the fixtures, and precision of the welding equipment itself. When proper alignment is achieved, comparatively little material needs to be melted and displaced to insure complete welding. At high speeds and pressures, melt is formed and displaced faster and is thus more difficult to control. However, high speeds can be used to promote centrifugal forcing of the melt away from the center of rotation, which increases external flashing, but acts to decrease internal flashing in hollow bodies.

The most important factor affecting flash is joint design. Joints may be designed which will produce varying quantities of flash, internal or external flash only, or retain all flashing within undercuts and pockets included in the joint, Fig. 11. In some applications, total elimination of flashing during welding may not be practical. Then a trimming operation can usually be included in the assembly process to produce an acceptable finish. In evaluating spin-welding for any application, the effect of flashing on the appearance and function of the finished part, and ways to eliminate it, should be considered.

Spin-Doweling: A combination of spin-welding

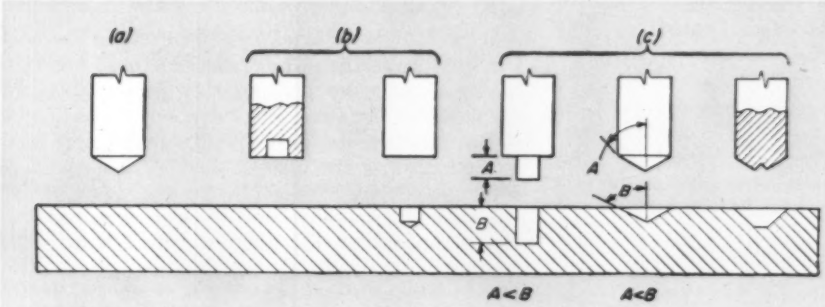


Fig. 10 — Velocity compensation may be provided by crown, *a*, or center removal in either part, *b*. Stronger joints are achieved by cantilever joint design, *c*.

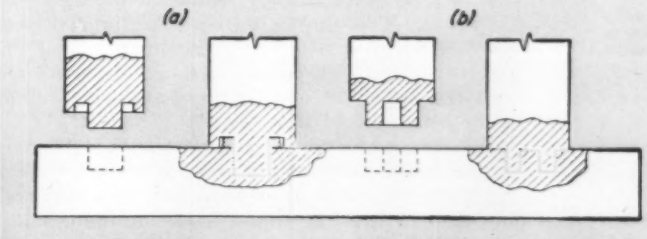


Fig. 11—Flash can be retained internally by a retainer ring, *a*, or by increase in joint surface, *b*.

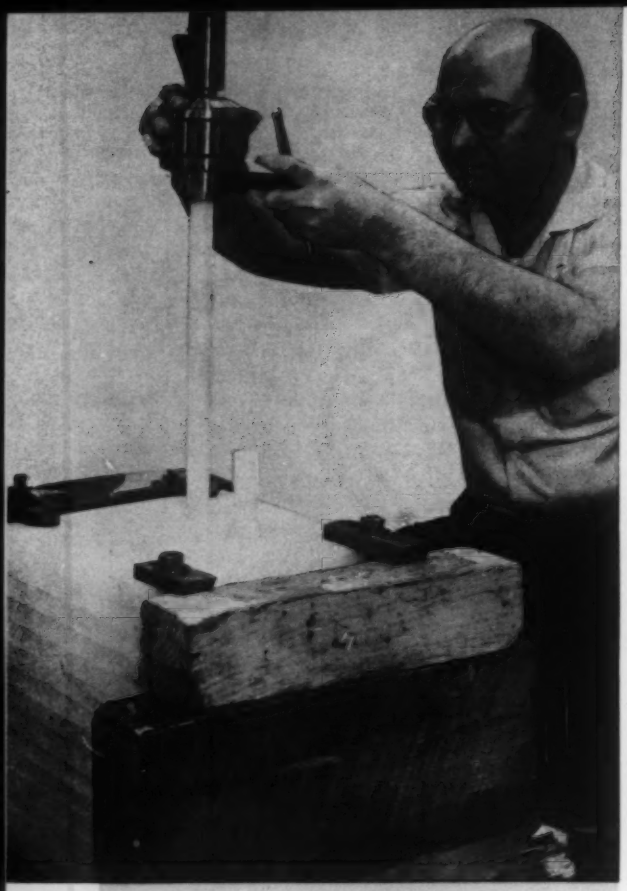


Fig. 12—Spin-welding is used to weld several sections together simultaneously

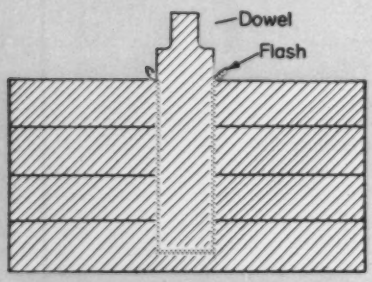


Fig. 13—Flash at top of spin-dowel is indication of completed weld. Dowel and flash may be trimmed flush.

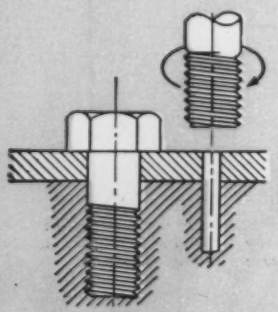


Fig. 14 — Metallic fasteners or inserts may be spin-welded in place

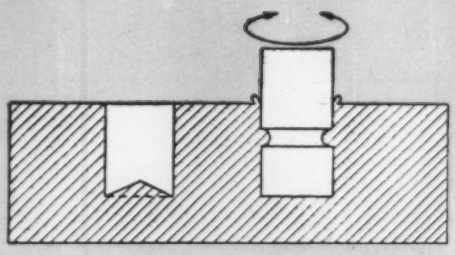


Fig. 15 — Metallic insert with circumferential groove has high axial strength but can be rotated

and dowel joining is useful for assembling thermoplastic sections into sizable composites. A dowel spun through several sections welds to, and effectively becomes a part of, each of these sections, holding them together so intimately that the resultant composite may be further processed as a solid unit. Production time and costs on large shapes may be significantly reduced by spin-doweling thin sections which require comparatively short molding cycles.

Parts to be joined are first aligned and clamped on a drill-press table, Fig. 12. A hole (if not already present) is drilled through the upper sections and part way through the last. Then a dowel, slightly longer than the combined thicknesses and a few thousandths smaller in diameter than the receiving hole, is gripped in the drill chuck and spun into the opening. The dowel bottoms in the last section, generating frictional heat which causes the material in the region of the rod tip to melt and flow up along the rod surface. When the melt flashes out of the top section, the rotation is stopped and the weld is formed, Fig. 13.

Since melt is obtained only in areas under contact pressure and must be displaced to weld non-contacting areas, more heat must be generated as the displacement requirements increase. Thus, for a rod of considerable length, high temperatures must be developed in the area of the rod tip to produce a complete bond. Unless the material to be welded has sufficient stability to withstand these localized high temperatures, the material may thermally degrade and the quality of the resultant weld will be poor. This thermal stability appears to be the limiting factor in spin-doweling large sections.

When spin-doweling, or using plugs in general, it is best to have the plug bottom at the center of the dowel. This may be accomplished by designing the dowel with a round or pointed end. Since the point or crown will contact first, all air is pushed from the center out and no trapped air will be left in the joint.

Where expense of preparation is not restricting, tapered holes and rods will produce the best results, Fig. 4 and 10. Melt is formed along the entire surface of a tapered rod, thus eliminating the problem associated with melt displacement. Generally, taper-

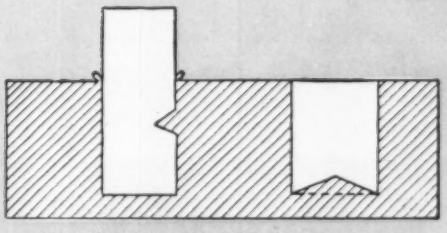


Fig. 16—Simple cross slot locks metallic insert against both axial and rotational forces

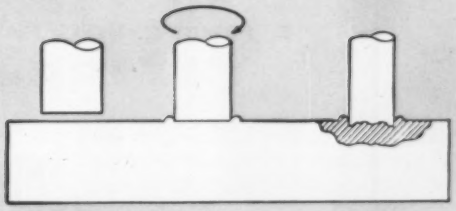


Fig. 17—Spin-molding is useful for low-production surface marking. Impression is a faithful mirror reproduction of surface finish and detail on die face.

ing is not required for polyethylene (straight spin-doweled sections over 15-in. thick have been produced without visible material degradation) or for acrylic (bubble-free thicknesses up to 4 in. have been obtained with molded and extruded sections). With nylon, air oxidation of the melt limits the strength of a spin-doweled joint and tapers are thus more important. With acetal resins, tapers are necessary to prevent degradation that occurs with very high temperatures and to minimize effect of shrinkage during transition from melt to solid.

Joint strength between the sections of a composite may be determined by standard stress-analysis procedures. Shear strength may be calculated by dividing the shearing load by the cross-sectional area of the spin-doweled rods times the shear strength of the material. Loads in tension may cause failure in either of two areas—at the weld or across the dowel face. The total dowel cross section times the tensile strength provides the strength across the block face. The section thickness (single section) times the total of rod circumferences times the shear strength of the weld provides the strength in tension on the axial weld area. Required dowel size and dowel spacing may be determined by working these calculations in reverse.

Bonding by Spin-Welding: In addition to the welding of similar thermoplastics, the spin-welding technique may be used to bond thermoplastics to plastics with a different melting point or to completely dissimilar materials. When spun against porous materials or against undercut nonporous materials, the plastic will melt and flow into the cavities of the mating part. The resulting member is a strong composite having the desirable qualities of both materials.

This technique has been used for a number of years to assemble plastic impact faces on wooden mallet heads, Fig. 4. It is also useful for assembling with screws and bolts, Fig. 14. Right-hand threads are spun in with a left-hand motion (and vice-versa), so that the melt is compressed into the cavity rather than carried out by the rotating screw thread. When the screw reaches its desired position, rotation is stopped; the threads are then effectively molded into the plastic, producing a joint of maximum strength and pleasing appearance. This technique also eliminates predrilling and tapping of holes.

Movable joints represent another application for this technique. With a smooth, circular undercut, a metal part may be attached to a plastic section so that it will have considerable axial strength, but will still be free to rotate when twisted, Fig. 15. If axial movement is undesirable, a simple cross slot is used, Fig. 16.

Sometimes it may be practical to substitute spin-welding of metallic sections for insert molding. When the insert is not complex it may generally be spin-welded into place, producing a joint as strong as that obtained by molding. This substitution is especially useful where a small number of parts are to be produced.

Localized Spin-Molding: A metallic die, spun against a thermoplastic (or vice-versa), will cause melting; by stopping the rotation and squeezing the die against the still-molten plastic, Fig. 17, an exact, mirrored image may be produced. Reproduction is so precise that a finely finished die will provide a polished finish in the plastic, similar to that obtained by ashing and buffing.

This technique is useful for finishing, labeling, and decorating standard items which are supplied to a number of users, each of whom desires special identification or innovations.

They Say . . .

"We can ill afford the luxury of continuing projects that have been given a fair trial and found wanting. The cleanest way to prevent this happening is to foster the utmost objectivity in the scientist himself. If the individual clearly understands that he is in large measure responsible for making the proper decision on faltering projects, half the battle has been won, and removing doubtful projects will prove less painful."—EMIL OTT, *director of research, and* CARL PRUTTON, *executive vice president, Food Machinery and Chemical Corp.*

The Personal Side of Engineering

By **EDWIN C. NEVIS** Personnel Research and Development Corp., Cleveland, Ohio

Improving Communications

POOR communication between engineers and management can have a strong effect on job effectiveness. Failure by top management to communicate policies and objectives adequately results in a lack of understanding and a feeling of isolation on the part of the engineers. And poor communication upward cuts off from top management knowledge about the attitudes and thoughts of the engineering group.

The fact that poor communications exist is evidenced by a study by the Professional Engineers Conference Board for Industry. In answer to the question, "Has your company conducted an attitude survey among its engineering employees within the last year," 92 per cent of the more than 1300 engineers studied replied "no." Only 58 per cent of the individuals questioned indicated that their company maintained a uniform system for evaluating the performance of engineers.

In another study of engineers, 61 per cent indicated that they were not kept properly informed of company policy and operations outside of their immediate assignment.

An attitude survey is an excellent technique for obtaining the opinions and feelings of employees so that management has the benefit of relatively uncensored comments about the way people feel toward their work and their company. The fact that so high a percentage of engineers in the study were not surveyed systematically does not necessarily mean that there was low morale, a great deal of dissatisfaction, or high turnover within their organizations. However, this statistic strongly suggests that engineers do not frequently have the opportunity to air their feelings, and their ideas and opinions, about how they are treated by their superiors and their company.

In effect, an attitude survey is a participation device which allows the engineer the opportunity to take part in the planning and policy-making function of the organization. This assumes, of course, that action will be taken upon the survey results.

A great deal of evidence also shows that engineers do not feel sufficiently well-informed about company policy. Apparently high on the list of what they would like to know more about are opportunities for advancement. In one study by the National Society for Professional Engineers, opportunities for advancement, expansion plans, and new products and processes contemplated were the subjects of most interest to engineers. In this same study, 92 per cent of the companies covered indicated that they looked to engineers for management personnel. Yet most of the companies reported no particular plan by which engineers could be given some idea about possible opportunities as managers. All of this indicates a gap in downward communication in many situations.

The relatively matter-of-fact and unemotional attitude most engineers demonstrate in the working situation can often lead management to believe that they are not interested in being informed. Any management which believes this statement can disabuse itself of it rather quickly by studying what engineers discuss in their "bull sessions" and during their lunch periods. The fact remains that engineers, like any other group of employees, are highly interested in what is going on in the company and what changes, new developments, and future opportunities are possible.

In a more personal way, there is a definite need on the part of the engineer to know where he stands, what his superiors think of his performance, and what his own personal prospects for the future are. Perhaps one of the most valuable communication techniques in terms of improving performance and creating a good working relationship with employees is the periodic performance review. This technique is also a development tool which allows superior and subordinate to sit down and take stock of the subordinate's performance, their own relationship, and how they function together. The procedure permits superior and subordinate to clear up any misunderstandings about work standards and job objectives. It also provides a means by which the engineer can learn where he stands in the eyes of his superior. This joint consideration of performance has the added value of helping the engineer to feel that the company is interested in him as an individual.

Performance planning reviews and attitude surveys are but two communication devices which serve to bring different levels of the organization closer together in their understanding of each other. While becoming widely used in industry today with both management and nonmanagement groups, these techniques are not very popular among engineering departments. Managements concerned with improving tenure and performance of engineering personnel might ask themselves whether they may be overlooking potentially valuable means of increasing job effectiveness and satisfaction.

Spring Design Charts

Part 1—Extension Springs

By H. J. BOLL
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Brooklyn, N. Y.

Charts and procedures presented in this two-article series were developed to provide a fast, simple method for design of extension and compression springs without need for the lengthy trial and error calculations usually involved. Based on the range of operating requirements most commonly encountered in practice, the approach also offers practical possibilities as a basis for standardization of these spring forms. This first article covers extension springs; a later article will deal with compression springs.

IN DESIGN of a spring, load and stress requirements must be met without exceeding prescribed space limitations. For a given set of operating conditions, any one of an infinite number of spring-dimension combinations is theoretically possible. However, if the number of permissible variations is reduced, standardization can be accomplished to the following extent:

1. Of the many available spring materials, music wire is the one commonly used for the general-purpose types of springs considered here. Let this material be a temporary standard. It will be shown later that spring design charts based on music wire can be used for any other material through application of suitable correction factors.

2. Music wire in the range from 0.012 to 0.124 in. diam comes in 36 sizes. The load characteristics of springs in these sizes so closely approximate each other that it is possible to eliminate half of them and standardize on 18 sizes.

3. The ratio of mean coil diameter to wire diameter or "spring index," is infinitely variable. Spring-index values of 6, 8, 10, and 12 can therefore be adopted as standard, eliminating all others. This conclusion is based on an extensive analysis of hundreds of existing nonstandard spring designs developed for a wide range of operating requirements. Results indicated

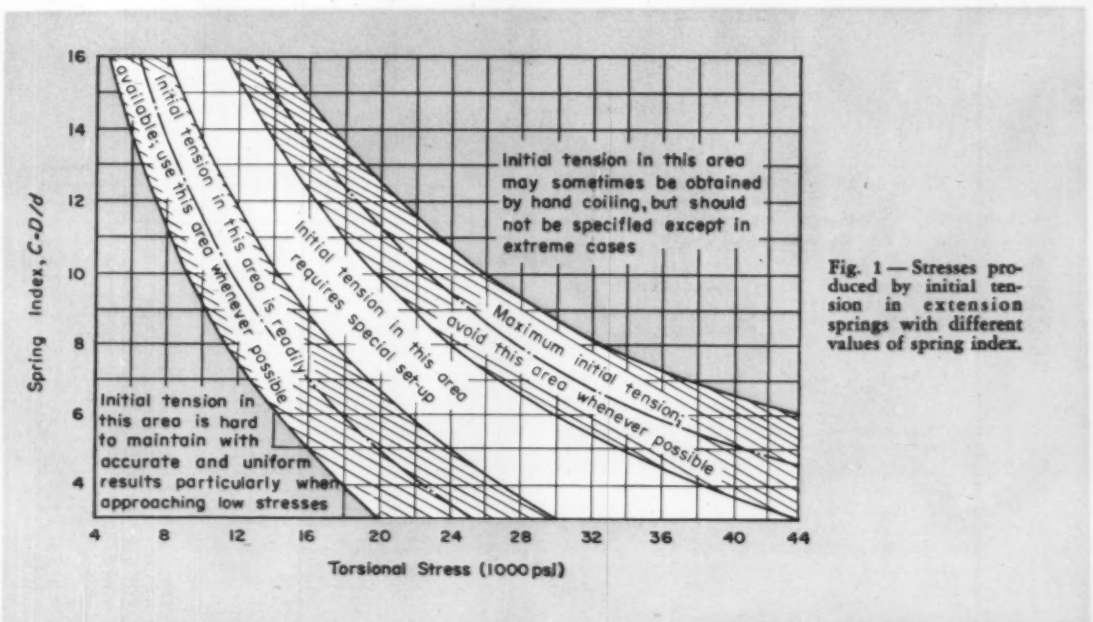


Fig. 1 — Stresses produced by initial tension in extension springs with different values of spring index.

that over 90 per cent of the springs fall within this spring-index range. Any one of these spring designs could readily have been modified to a standard index and still have met all requirements of load, stress, deflection and space limitations.

The value of spring standardization may well be questioned. When springs of the type under consideration here are produced in quantity it is not expensive to change from one coil and wire size to another. Thus, it is of little consequence, costwise, whether or not the springs have anything in common. In the prototype or small-quantity shop, however, it is often more practical to wind the few springs required in the shop. In this case, it is convenient to have "standard" coils available in 1 to 3 ft lengths from which almost any spring can be made by merely cutting the lengths required from the stock coil.

Another advantage of standardization occurs where a certain spring design becomes obsolete while there are still hundreds in stock. These can often be salvaged for some other application by merely altering the length.

Nomenclature

B = Length of spring body, in.
$C = D/d$ = Spring index
D = Mean diameter of spring, in.
d = Wire diameter, in.
F = Total actual spring deflection, in.
f_a = Actual deflection per coil, in.
f_{it} = Theoretical deflection per coil required to produce the stress developed by initial tension, in.
f_t = Total deflection per coil, Equation 1, in.
G = Torsional modulus of elasticity, psi
N = Number of coils in spring
P = Applied load, lb
S_a = Actual torsional stress, psi
S_{it} = Torsional stress developed by initial tension, psi
S_t = Total torsional stress, Equation 2, psi
Y = Stress correction factor (Wahl), Fig. 4

Extension-Spring Design: Before examining basic spring equations, it should be noted that extension springs are usually wound with initial tension. The coils are wound so tightly that an appreciable load must be applied before any deflection takes place. The stress resulting from this initial tension may run as high as 25 per cent of the maximum allowable stress, Fig. 1.

To develop simple charts for designing extension springs that meet the previously mentioned standards, consider first the two fundamental relationships from which practically all other helical spring equations for round wire are derived:

$$f_t = \frac{\pi S_t D^2}{GdY} \qquad (1)$$

(*Text continued on Page 143*)

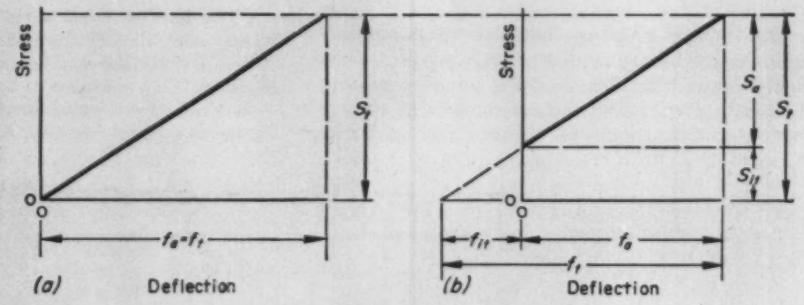


Fig. 2—Effect of initial tension on stress-deflection relationship of extension springs showing, *a*, spring wound without initial tension and, *b*, spring wound with initial tension in coils

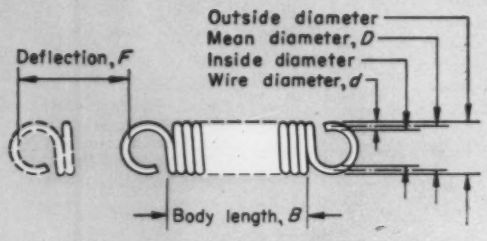


Fig. 3—Above—Basic design details for extension spring of conventional form

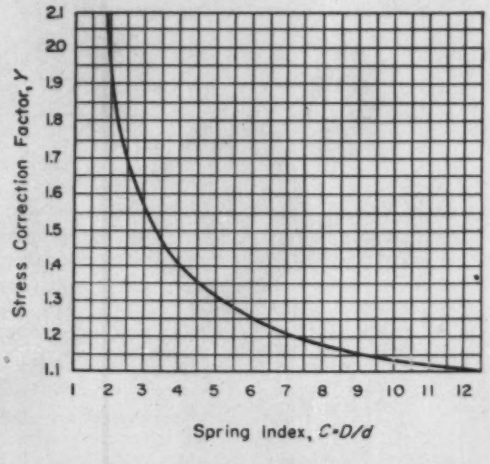


Fig. 4—Right—Wahl stress correction factor for effect of curvature in helical round-wire extension or compression springs

DESIGN CHART 1 — Extension Springs

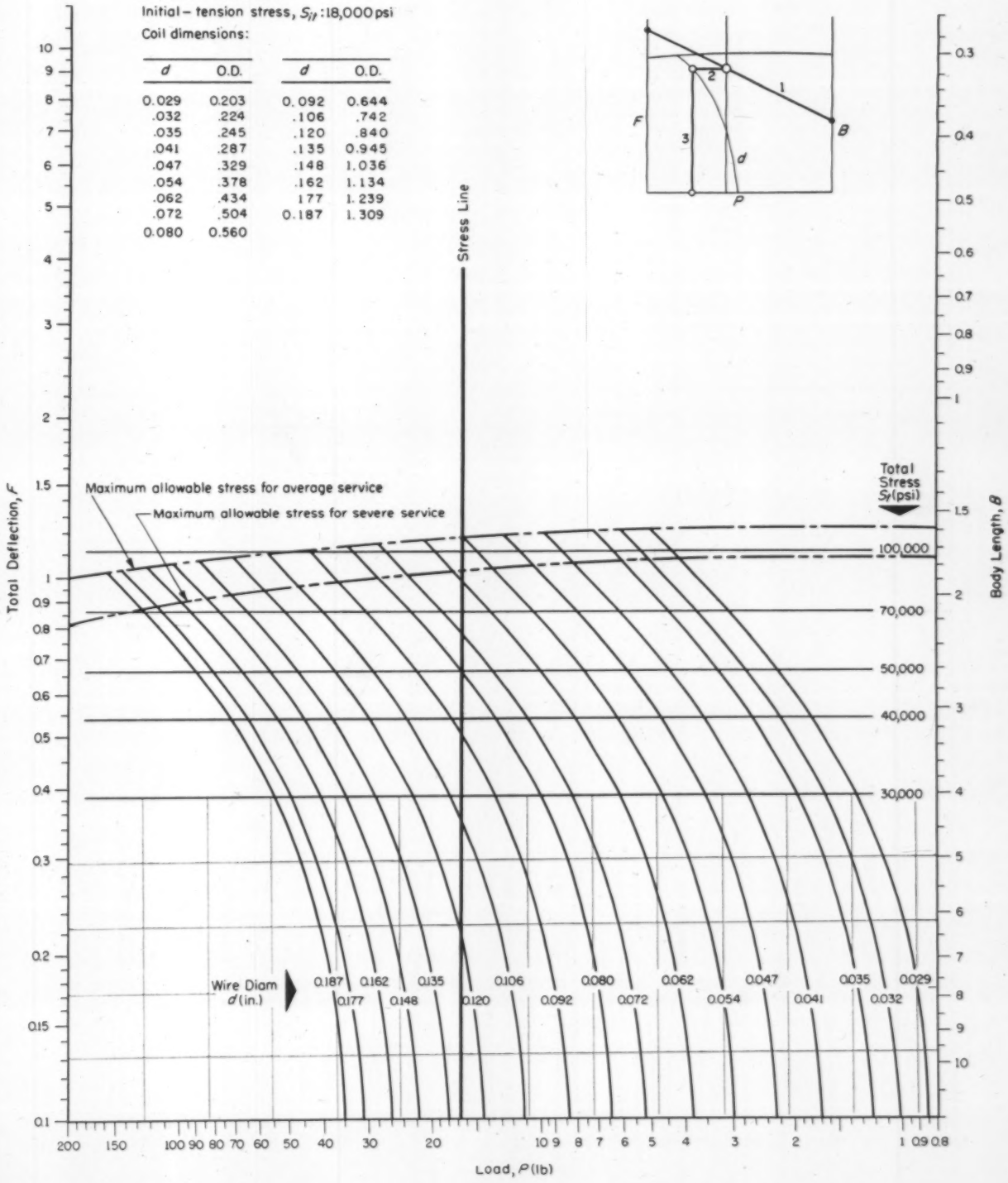
$C = D/d = 6$

Material: Music wire

Initial-tension stress, S_{ii}: 18,000 psi

Coil dimensions:

d	O.D.	d	O.D.
0.029	0.203	0.092	0.644
.032	.224	.106	.742
.035	.245	.120	.840
.041	.287	.135	0.945
.047	.329	.148	1.036
.054	.378	.162	1.134
.062	.434	177	1.239
.072	.504	0.187	1.309
0.080	0.560		

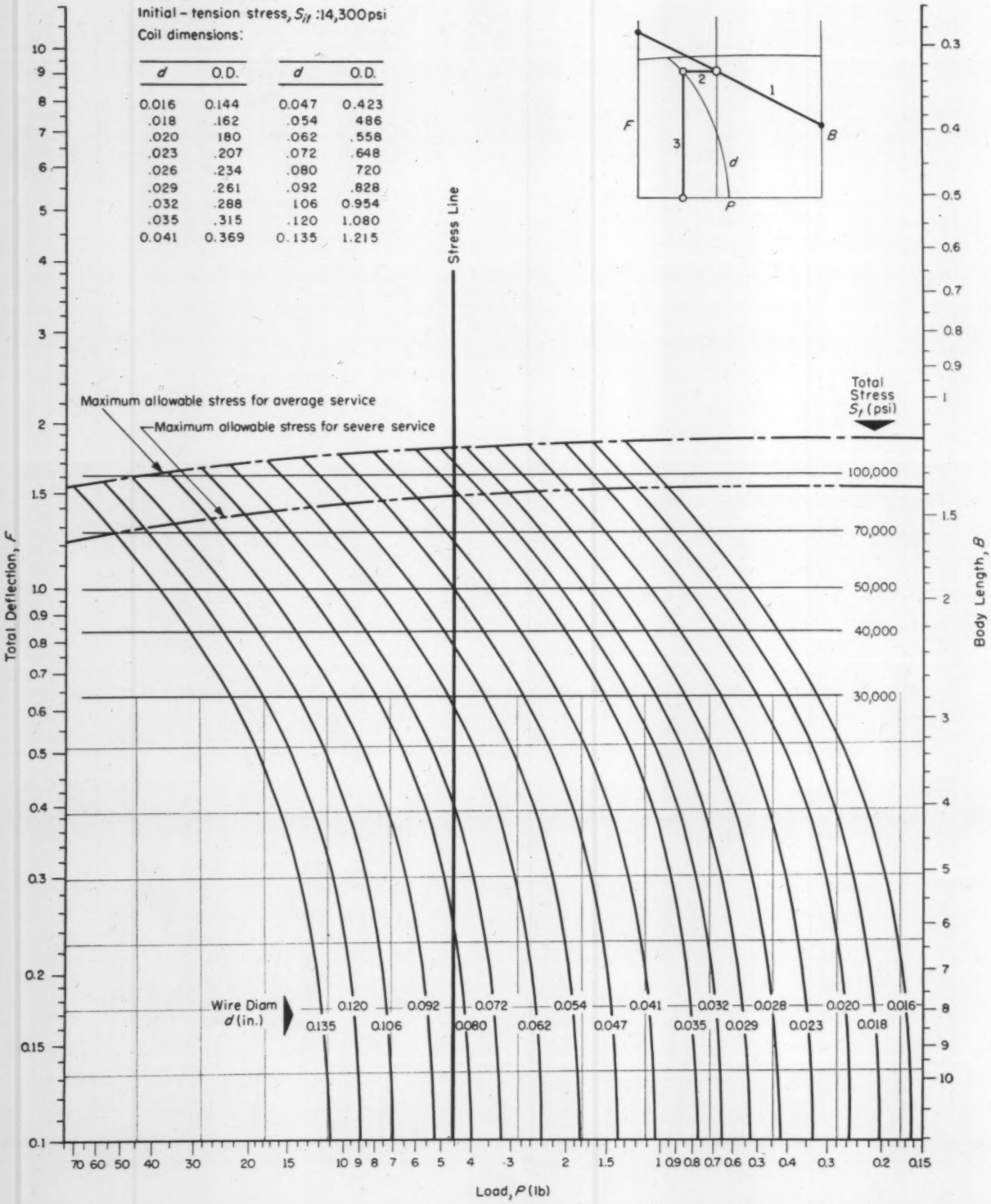


DESIGN CHART 2 – Extension Springs

$C = D/d = 8$

Material: Music wire
Initial-tension stress, S_i: 14,300 psi
Coil dimensions:

d	O.D.	d	O.D.
0.016	0.144	0.047	0.423
.018	.162	.054	486
.020	180	.062	.558
.023	.207	.072	.648
.026	.234	.080	720
.029	.261	.092	.828
.032	.288	106	0.954
.035	.315	.120	1.080
0.041	0.369	0.135	1.215



DESIGN CHART 3 — Extension Springs

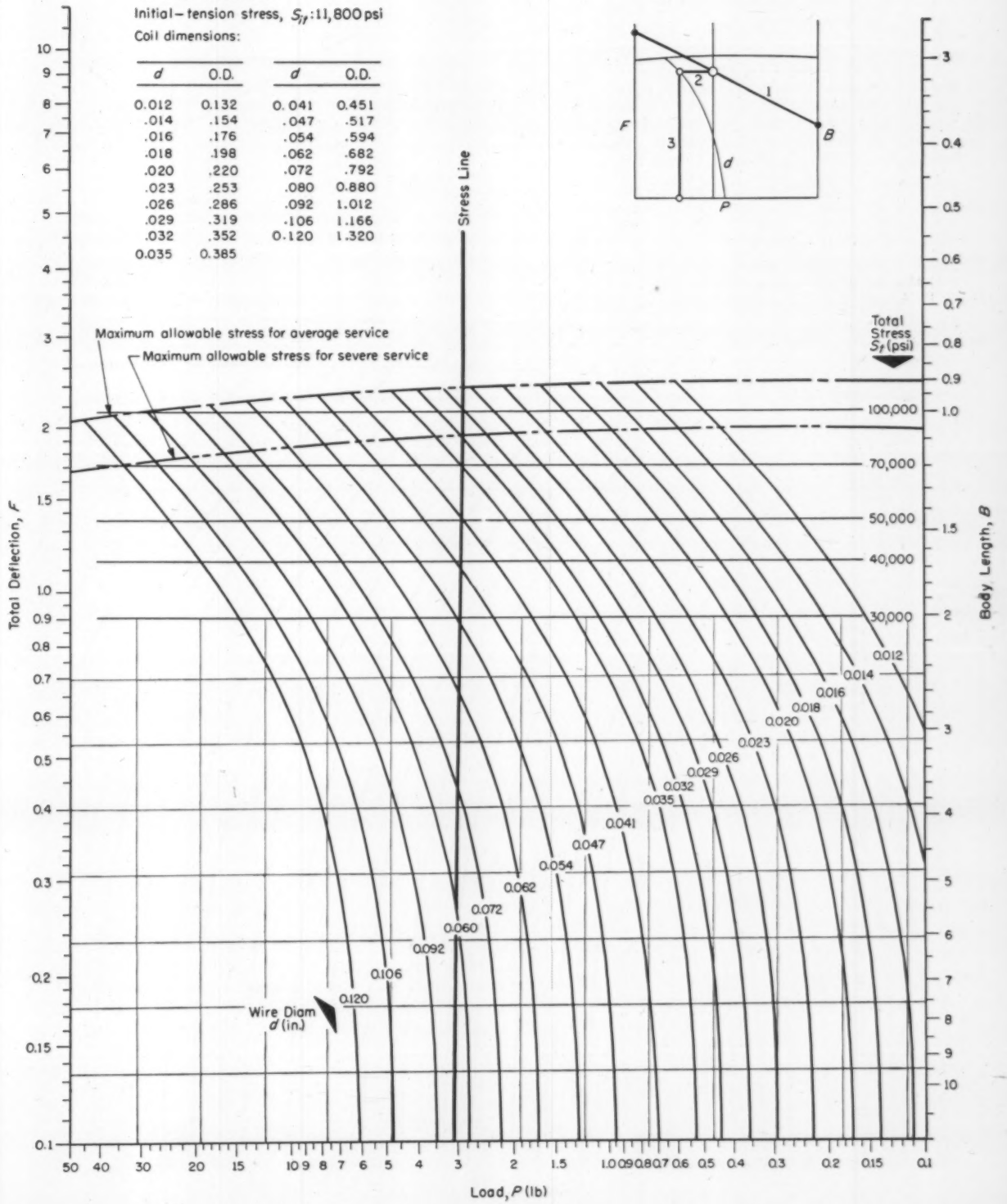
$C = D/d = 10$

Material: Music wire

Initial-tension stress, S_{ii}: 11,800 psi

Coil dimensions:

d	O.D.	d	O.D.
0.012	0.132	0.041	0.451
.014	.154	.047	.517
.016	.176	.054	.594
.018	.198	.062	.682
.020	.220	.072	.792
.023	.253	.080	0.880
.026	.286	.092	1.012
.029	.319	.106	1.166
.032	.352	0.120	1.320
0.035	0.385		

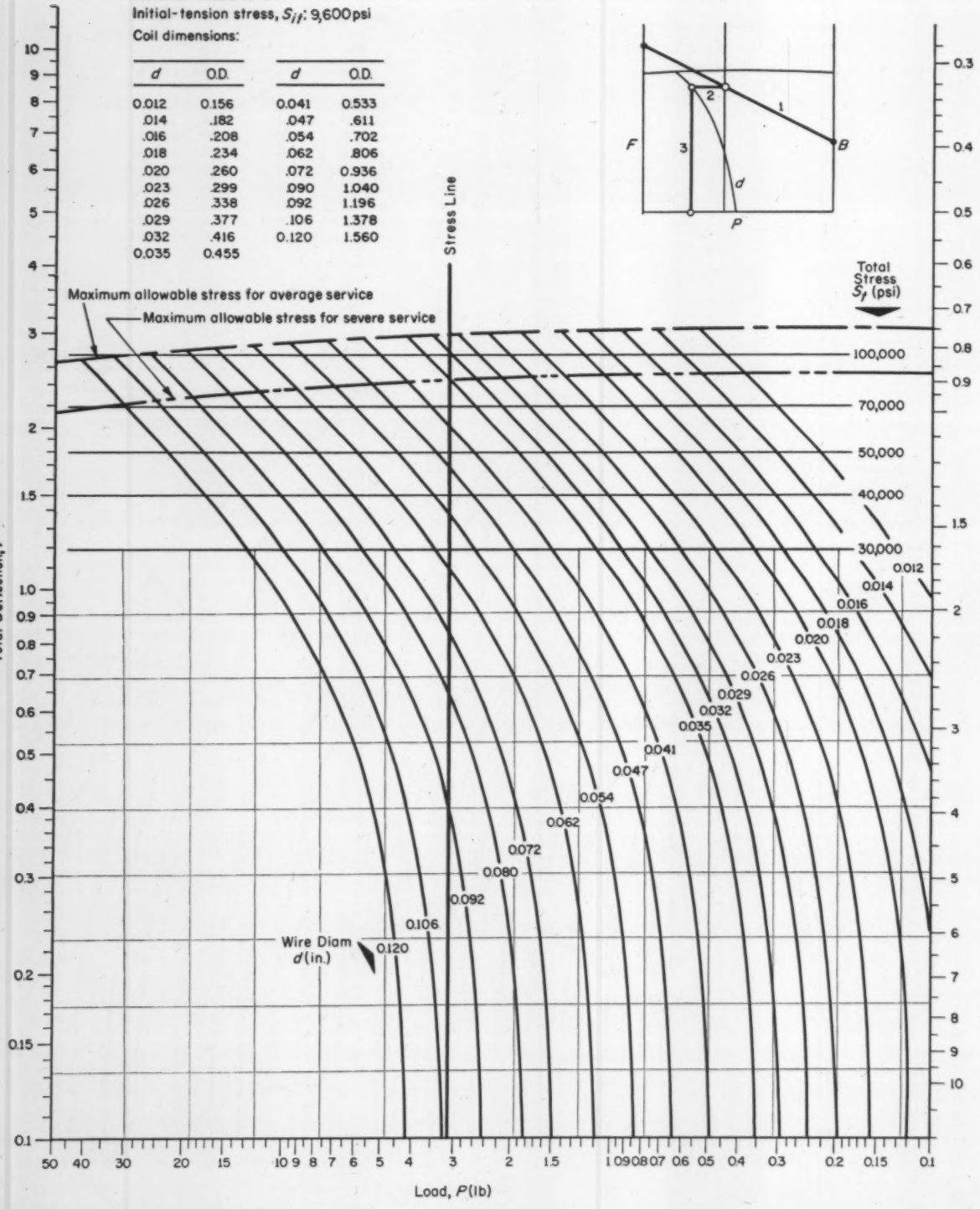


DESIGN CHART 4 – Extension Springs

$C = D/d = 12$

Material: Music wire
Initial-tension stress, S_{ii}: 9,600 psi
Coil dimensions:

d	O.D.	d	O.D.
0.012	0.156	0.041	0.533
.014	.182	.047	.611
.016	.208	.054	.702
.018	.234	.062	.806
.020	.260	.072	0.936
.023	.299	.090	1.040
.026	.338	.092	1.196
.029	.377	.106	1.378
.032	.416	0.120	1.560
0.035	0.455		



$$S_t = \frac{2.55\,PDY}{d^3} \tag{2}$$

where symbols are defined in Nomenclature and Fig. 2 and 3.

The effect of initial tension on spring analysis is shown in Fig. 2. A spring wound without initial tension will start to deflect as soon as load is applied, Fig. 2*a*, while a spring wound with initial tension, Fig. 2*b*, will not deflect until the load is sufficient to overcome the initial tension.

For springs without initial tension, $f_t = f_a$ and $S_t = S_a$. But for springs wound with initial tension,

$$f_t = f_a + f_{it} \tag{3}$$

$$S_t = S_a + S_{it} \tag{4}$$

Thus, the total stress is the sum of the stress created by initial tension and the stress produced by the actual deflection. Evaluation of these stresses is covered in the following discussion.

By substitution in Equation 1,

$$f_{it} = \frac{\pi\, S_{it}\, D^2}{G d\, Y} \tag{5}$$

From Fig. 1, initial-tension stress S_{it} is a constant for a given value of spring index. Deflection per coil f_{it}, then, is also a constant for each index value. Similarly, from Equation 1,

$$f_a = \frac{\pi\, S_a\, D^2}{G d\, Y} \tag{6}$$

Combining Equations 3, 5, and 6,

$$f_t = \frac{\pi\, D^2}{G d\, Y}\left(S_{it} + S_a\right) \tag{7}$$

It will be noted that Equations 2 and 7 both contain the spring index term, $C = D/d$. For simplicity, one design chart has been developed for each standard index: $C = 6$, 8, 10 and 12. Thus, C is a constant for each chart.

In Equation 7, relationships are given in terms of deflection per coil. The usual approach is to assume this value and then prove it by trial and error. It is much simpler to specify the required total deflection, F, which is a known quantity. By definition,

$$F = f_a N \tag{8}$$

Ordinarily, the number of coils is determined by trial and error. However, body length B, Fig. 3, can be accurately estimated from space limitations before the spring is designed and, thus, is a more practical quantity than N for calculation purposes. By definition,

$$B = Nd \tag{9}$$

From Equation 8, substituting B/d for N and solving for f_a,

$$f_a = \frac{Fd}{B} \tag{10}$$

Then, substituting this value of f_a in Equation 6,

$$\frac{F}{B} = \frac{\pi\, D^2}{G d^2\, Y}\, S_a = k\, S_a \tag{11}$$

where k is a constant for a given spring index and material.

Values of the Wahl stress correction factor, Y, for curvature effect can be determined from Fig. 4 for different spring index values. For $C = 8$, $Y = 1.18$ and Equation 11 becomes

$$S_a = \frac{F}{1.48(10^{-5})\, B} \tag{12}$$

From Equation 12, it is apparent that all springs with the same spring index and ratio F/B will be stressed to the same extent, regardless of wire size, body length or total deflection.

Graphical Approach: Design Charts 1, 2, 3, and 4 represent a simplified graphical solution to the foregoing expressions for design of extension springs with standard indexes of $C = 6$, 8, 10, and 12, respectively. Similar charts for compression springs will be presented in a later article.

In these charts, based on Equation 12, values of total deflection F and body length B appear as parallel logarithmic scales. The Stress Line, which is also parallel to the F and B scales is located on each chart by drawing several lines from the F scale to the B scale, corresponding to the same value of ratio F/B in each case. For example, a line from $F = 0.1$ to $B = 1$ gives $F/B = 0.1$. Similarly, a line from $F = 0.5$ to $B = 5$ also gives $F/B = 0.1$. Intersection of these lines locates the Stress Line.

Construction of the Stress Line represents a graphical solution of Equation 12 for actual stress S_a. However, since S_{it} is constant for a given spring index, stress scales (perpendicular to Stress Line) have been located so that points along the Stress Line can be read directly in terms of total stress S_t, effectively solving Equation 4.

To plot the load (P) scale it will be convenient to revise the form of some of the previous equations. Combining Equations 2 and 4,

$$S_a + S_{it} = \frac{2.55\,PDY}{d^3} \tag{13}$$

and then substituting Equation 12 into Equation 13,

$$\frac{F}{1.48(10^{-5})B} + S_{it} = \frac{2.55\,PDY}{d^3} \tag{14}$$

For each chart, of course, $C = D/d$ is a constant. Also, on these charts it will be seen that one wire curve is drawn for each wire size. Thus, d is a constant for each of these curves.

In Design Chart 2 for $C = 8$, $Y = 1.18$ (Fig. 4) and $S_{it} = 14{,}300$ psi (Fig. 1) for all wire sizes. Substituting these values in Equation 14,

$$P = \frac{d^2\left(\dfrac{F}{1.48(10^{-5})B} + 14{,}300\right)}{2.55(8)(1.18)} \tag{15}$$

As a check on chart accuracy, assume $F = 0.1$ in.,

B = 12 in. and d = 0.120 in. From Equation 15, P = 8.89 lb which agrees with the chart value for 0.120-in. wire. To plot other points on the wire curves, assume an arbitrary series of values for F and B and draw the corresponding connecting lines on the chart. Where these lines intersect the Stress Line, draw perpendiculars (parallel to stress-scale lines). Then solve for P in Equation 15 for each value of F/B and d, and plot these points along the perpendicular lines. The wire curves are terminated at the point of maximum allowable stress to prevent inadvertently designing for a condition which would overstress the spring. Values of maximum allowable stress used here are given in Table 1.

Chart Application: For purposes of standardization, as well as good design practice, Design Chart 2 for spring index C = 8 is the preferred chart. It will always be used unless, as outlined in the following discussion, special circumstances dictate otherwise.

Table 1—Maximum Allowable Stresses for Music-Wire Extension Springs

Wire Size, d (in.)	Maximum Allowable Stress (psi) Average Service	Severe Service
0.016	89,000	121,000
.023	86,500	118,000
.035	84,000	114,500
.054	81,500	111,000
.072	78,000	106,000
.106	72,000	98,000
0.135	70,200	95,500

Table 2—Material Correction Factors for Spring Design Charts

Material	Torsional Modulus (psi)	Correction Factor*
Music wire	11,500,000	1.000
Oil-tempered wire	11,500,000	1.000
Hard-drawn spring wire	11,500,000	1.000
Type 302 stainless	10,000,000	0.870
Monel	9,500,000	0.826
Phosphor bronze	6,250,000	0.543
Brass	5,500,000	0.478

*Multiply chart values of load and stress by this factor.

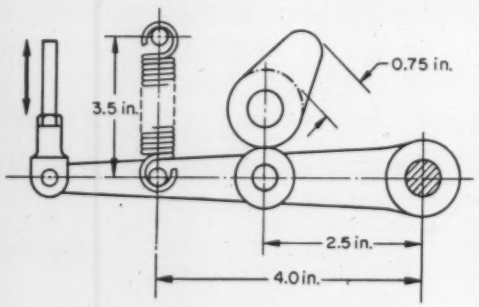


Fig. 5—Design details of cam-follower system for extension-spring design problem

In the use of the charts, the following procedure is recommended. It is assumed that space limitations, load requirements and deflection are known or can be readily determined.

1. Assume values for body length B and total deflection F. Total deflection will equal the amount that the spring deflects in service, plus an arbitrary initial deflection required to pull the spring taut between the spring posts.

2. On Design Chart 2, draw a line between the F scale and the B scale connecting the values assumed in Step. 1. The intersection of this line with the Stress Line gives the resulting total stress, S_t.

   a. If this stress is too high, modify F or B, if possible. Practical modifications include changing the distance between spring posts, changing post diameter, or changing the amount of initial deflection required to hook the spring securely in place.

   b. If Step 2*a* is not possible, try one of the other design charts.

3. Draw a line parallel to the P scale through the intersection point on the Stress Line found in Step 2. Where this line intersects the various wire curves, draw lines parallel to the Stress Line to intersect the P scale. These intersection points give the load values at total stress S_t (Step 2) for the various wire sizes under the assumed F and B conditions.

   a. If these load values do not meet design requirements, draw a line through the exact load required. Where this line intersects the wire curves, draw lines parallel to the P scale to intersect the Stress Line. With this point of intersection as a pivot, draw a line between F and B scales by swinging about the pivot point until acceptable values of F and B are obtained.

   b. If Step 3*a* does not provide the solution, it may be possible to alter the distance between, or diameter of, spring posts. As a final resort, try another design chart.

In these charts, the scales for total deflection F and body length B have no units of length. Either inches, feet, centimeters, or other units may be used as long as they are consistent. Also, both scales can be multiplied by the same factors. That is, a 2 in. long spring with 1½ in. deflection will be stressed the same as a 4-in. spring with 3-in. deflection.

These charts also can be used for materials other than music wire by using the constants given in Table 2. Deflection, stress and load are all proportional to the modulus in torsion (Equations 1 and 2). The charts should not be used for beryllium-copper springs which always have zero initial tension.

Example Problem: For the cam-follower system shown in Fig. 5, design an extension spring which will hold the cam roller in contact with the cam throughout the operating cycle. Design assumptions are:

1. Load required to maintain contact at low point of cam, P_1 = 5 to 6 lb.
2. Maximum load at high point of cam contact, P_2 = 10 to 15 lb.
3. Spring post diameter, D_p = 0.25 in.
4. Spring deflection required to pull spring taut at low

point of cam contact, F_s = 0.5 in.

5. Body length, B = 2.50 in. For spring body to fit between spring posts, length cannot exceed approximately 3 in. When hooked to spring posts, body has already been extended 0.5 in., based on the foregoing assumption for F_o. Thus, free body length will be approximately 3 − 0.5 = 2.5 in.

All of these assumptions are necessary, whether the design charts are used or not.

From Fig. 5, it is evident that a cam rise of 0.75 in. will cause the spring to deflect 1.2 in. This distance plus deflection F_0 (assumption 4), gives total deflection F = 1.7 in.

On Design Chart 2, draw a line from F = 1.7 to B = 2.5. Intersection of this line with the Stress Line gives total stress S_t = 60,000 psi, which is safe for either severe or average service. Through this intersection point, draw a line parallel to the P scale. Where this line intersects the various wire curves, draw lines to intersect the P scale. For wire diameter d = 0.072 in., read load P = 13 lb (approximately). This value satisfies assumption 2.

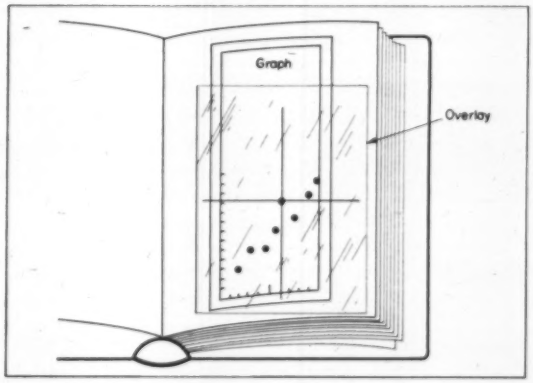
Now connect F = 0.5 with B = 2.5, and repeat the foregoing procedure. Under these conditions, for d = 0.072 in., P = 6 lb. This result satisfies assumption 1.

Based on the chart solution, extension spring proportions are:

1. Wire size, d = 0.072 in.
2. Mean diameter, D = 0.576 in.
3. Outside diameter = 0.648 in.
4. Inside diameter = 0.504 in.
5. Body length, B = 2.500 in.

Now that the spring has been designed, the adequacy of the assumed body length must be checked. From Fig. 3, the length of spring between the spring loops is B + 1.5 × ID or 2.50 + 1.5 (0.504) = 3.256 in. Distance across the outside of the spring posts is 3.50 + 0.25 = 3.750 in. Therefore, the spring must be deflected 3.750 − 3.256 = 0.494 in., or about 0.50 in., to hook it over the spring posts. Since this condition satisfies assumption 4, the assumed body length is satisfactory.

Tips and Techniques



Ordinate Template

A flexible sheet of 8½ x 11½-in transparent plastic (such as a photographic negative), marked with inked lines at right angles, can be used to locate points on a graph. If the template is pierced to fit a pencil point at the intersection of the lines, new positions can also be marked on the graph. This is a handy tool if the graph has been bound in a book or is otherwise mounted so as to hinder easy handling. The template can be quickly made by ruling marks on mending tape, such as Scotch No. 810, and applying the tape to the plastic.—ROBERT L. EBERHARDT, *Todd Shipyards Corp., San Pedro, Calif.*

Solving Quadratic Equations

The slide rule can be used to solve a quadratic equation if it is first reduced to the form $x^2 + bx + c$, the coefficient of x^2 being unity. For real roots, $b^2 > 4c$. If the roots are m and n, then $(x + m)(x + n) = 0$. Algebraic sum of the roots equals $b = m + n$, and the product of the roots equals $c = mn$.

As an example, consider $x^2 + 4.196x + 4.15 = 0$. Then, $m + n = 4.196$ and $mn = 4.15$.

Set the cursor with the hairline over 4.15 on the D scale. For any relative position of C and D scales, the reading on the C scale under the hairline, when multiplied by the reading on the D scale under unity on the C scale, will have a product equal to 4.15.

By a judicious sliding of the C scale, a setting will be obtained where the sum of the two values will be 4.196. This is obtained by two values just a little below 2.6 and 1.6, respectively. A more accurate reading is possible on the lower value as 1.598 and the higher value can be read off as 2.598 to give the sum as 4.196. Thus, $(x + 2.598)(x + 1.598) = 0$ and $x = -2.598$ or -1.598.

The same setting affords a result for $x^2 - 4.196x + 4.15 = 0$; $(x - 2.598)(x - 1.598) = 0$ and $x = 2.598$ or 1.598. Where the roots are of opposite sign, as $x^2 - x - 4.15 = 0$, $(x - 2.598)(x + 1.598) = 0$, $x = 2.598$ or -1.598.—ALEX B. CARR, *lecturer in machine design, Ryerson Institute of Technology, Toronto, Ont.*

Calculating Velocities and Accelerations in

FOUR-BAR LINKAGES

By GEORGE H. MARTIN
Associate Professor of Mechanical Engineering
Michigan State University
East Lansing, Mich.

SOME general equations are presented here for the four-bar linkage. They give angular positions, velocities, and accelerations of the connecting link and the driven crank in terms of angular position, velocity, and acceleration of the driving crank. In addition, it is shown how linear velocity and acceleration of any point on the linkage can be computed.

Generally, velocities and accelerations can be found quickest graphically, using the well-known relative-velocity and acceleration methods. However, mathematical analysis is advantageous under certain circumstances—for example, when greater accuracy is desired. This would be particularly true for mechanisms in which the relative size of the links, or instantaneous positions of the links, is such that graphical results would be subject to large error. Such errors may arise because of the difficulty in accurately determining the point of intersection on a drawing—for example, the point of intersection of nearly parallel lines. Furthermore, mathematical analysis can be of value from the standpoint of systematic design.

Position: A four-bar linkage is represented in Fig. 1. Let a, b, c, and d denote the lengths of links 1, 2, 3, and 4, respectively. The frame or fixed member is regarded as link 1. Angles θ_2, θ_3, and θ_4 denote the angular positions of links 2, 3, and 4, respectively, and are considered positive when measured counterclockwise as shown. The length of the diagonal from A to D is denoted by l, and the angle which it makes with line OD is indicated as β. Link 2 is considered as the driver and its angular position θ_2 is assumed known.

Angles θ_3 and θ_4 can be found by trigonometry as follows: Consider triangle OAD.

$$l = (a^2 + b^2 - 2ab\cos\theta_2)^{1/2} \tag{1}$$

and

$$\frac{\sin\beta}{b} = \frac{\sin\theta_2}{l}$$

Thus,

$$\beta = \sin^{-1}\left(\frac{b}{l}\sin\theta_2\right) \tag{2}$$

Next, for triangle ABD,

$$d^2 = c^2 + l^2 - 2cl\cos\psi$$

Hence,

$$\psi = \cos^{-1}\left(\frac{c^2 + l^2 - d^2}{2cl}\right) \tag{3}$$

To find θ_3, consider the configuration of the linkage. When line AB intersects line OD outside of the length OD, as illustrated in Fig. 1, let this be called Case 1. When line AB intersects line OD inside the length OD, as illustrated in Fig. 2, then let this be Case 2. Thus,

$$\left.\begin{aligned}\text{Case 1:}\quad \theta_3 &= \psi - \beta\\ \text{Case 2:}\quad \theta_3 &= \psi + \beta\end{aligned}\right\} \tag{4}$$

Next, from triangle ABD,

$$\frac{\sin\lambda}{c} = \frac{\sin\psi}{d}$$

Hence,

$$\lambda = \sin^{-1}\left(\frac{c}{d}\sin\psi\right) \tag{5}$$

The expression for θ_4 likewise depends upon the

. . . a simple algebraic method based upon complex numbers for precise determination of motion properties

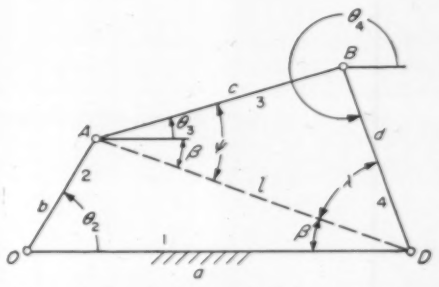


Fig. 1—Four-bar linkage, Case 1: Line *AB* intersects line *OD* outside of the length *OD*.

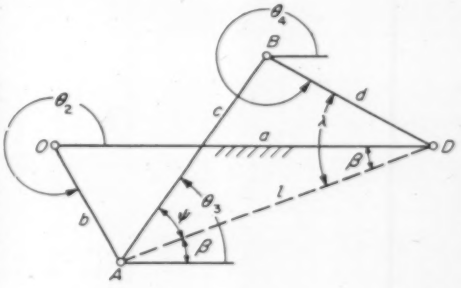


Fig. 2—Four-bar linkage, Case 2: Line *AB* intersects line *OD* inside of the length OD.

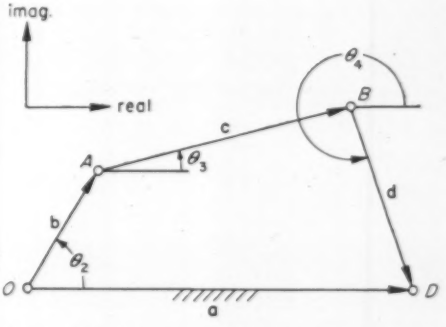


Fig. 3—Position vectors for a four-bar linkage.

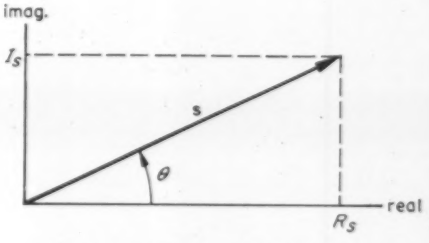


Fig. 4 — Real and imaginary components of a vector.

configuration of the linkage:

$$\left.\begin{array}{ll}\text{Case 1:} & \theta_4 = 2\pi - \lambda - \beta \\ \text{Case 2:} & \theta_4 = 2\pi - \lambda + \beta\end{array}\right\} \qquad (6)$$

where Case 1 and Case 2 are as defined previously. Thus from the known lengths of the links, the values of θ_3 and θ_4 can be determined for any chosen value of θ_2 by using Equations 1 through 6.

Velocities: In Fig. 3 a four-bar linkage is shown with the links represented by position vectors **a, b, c,** and **d.** A convenient method of expressing vectors is to write them as complex numbers. That is any vector can be expressed as the sum of a real number and an imaginary number. Consider vector **s** in Fig. 4.

$$\mathbf{s} = R_s + iI_s$$

where R_s and I_s are real numbers and are the magnitudes of the real and imaginary components, respectively, of **s**. The quantity $i = \sqrt{-1}$. Furthermore, the magnitude of vector **s** is s, and

$$s = (R_s^2 + I_s^2)^{1/2} \qquad (7)$$

The angle θ which the vector makes with the real axis denotes its direction:

$$\theta = \tan^{-1}\frac{I_s}{R_s} \qquad (8)$$

From Fig. 4 it is seen that $R_s = s\cos\theta$ and $I_s = s\sin\theta$. Thus,

$$\mathbf{s} = s(\cos\theta + i\sin\theta)$$

However,

$$\cos\theta + i\sin\theta = e^{i\theta}$$

which can be verified from the Maclaurin series

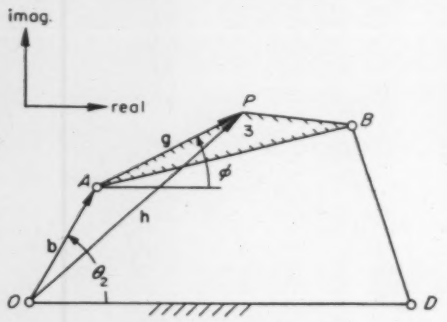


Fig. 5—Position vector for a point on link 3 in a four-bar linkage.

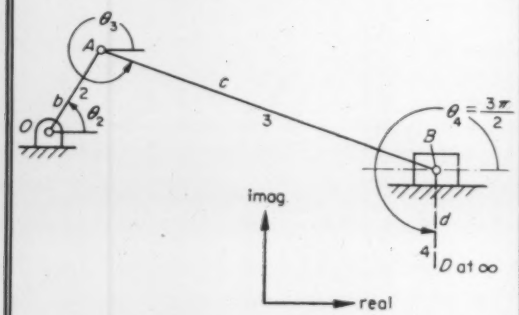


Fig. 6—Slider-crank mechanism, a special case of the four-bar linkage.

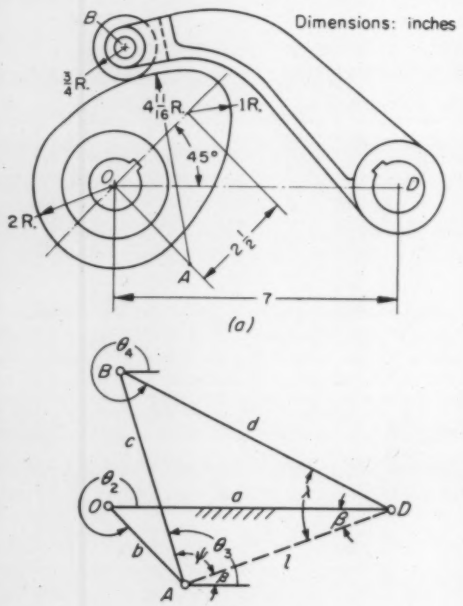


Fig. 7—Cam mechanism and equivalent four-bar linkage.

expansion of $\cos\theta$, $\sin\theta$, and $e^{i\theta}$. Hence,

$$\mathbf{s} = se^{i\theta}$$

which expresses the vector in exponential form.

Referring again to Fig. 3, and noting that the position of point D relative to point O is specified by position vector **a**,

$$\mathbf{b} + \mathbf{c} + \mathbf{d} = \mathbf{a} \tag{9}$$

Expressing these vectors in exponential form,

$$\left.\begin{aligned} \mathbf{a} &= ae^{i\theta_1} = a \\ \mathbf{b} &= be^{i\theta_2} \\ \mathbf{c} &= ce^{i\theta_3} \\ \mathbf{d} &= de^{i\theta_4} \end{aligned}\right\} \tag{10}$$

Substituting Equations 10 into Equation 9,

$$be^{i\theta_2} + ce^{i\theta_3} + de^{i\theta_4} = a$$

Next, if we differentiate this equation with respect to time and designate the angular velocities by $d\theta_2/dt = \omega_2$, $d\theta_3/dt = \omega_3$, and $d\theta_4/dt = \omega_4$,

$$ib\omega_2 e^{i\theta_2} + ic\omega_3 e^{i\theta_3} + id\omega_4 e^{i\theta_4} = 0 \tag{11}$$

The real and imaginary parts of this equation are

$$\left.\begin{aligned} &\text{Real: } -b\omega_2 \sin\theta_2 - c\omega_3 \sin\theta_3 - d\omega_4 \sin\theta_4 = 0 \\ &\text{Imag.: } b\omega_2 \cos\theta_2 + c\omega_3 \cos\theta_3 + d\omega_4 \cos\theta_4 = 0 \end{aligned}\right\} \tag{12}$$

Equation 12 can be solved for ω_3 and ω_4:

$$\omega_3 = -\frac{b \sin\delta}{c \sin\varepsilon}\omega_2 \tag{13}$$

$$\omega_4 = \frac{b \sin\gamma}{d \sin\varepsilon}\omega_2 \tag{14}$$

where

$$\left.\begin{aligned} \delta &= \theta_2 - \theta_4 \\ \varepsilon &= \theta_3 - \theta_4 \\ \gamma &= \theta_2 - \theta_3 \end{aligned}\right\} \tag{15}$$

Thus, from Equations 13 and 14, the angular velocities of links 3 and 4 can be obtained from the known velocity of link 2.

Having found the angular velocity of link 3, compute the linear velocity for any point on the link as follows: In Fig. 5 let P be a point whose linear velocity is to be found. Position **h** is then $\mathbf{h} = \mathbf{b} + \mathbf{g}$, or in exponential form,

$$\mathbf{h} = be^{i\theta_2} + ge^{i\phi} \tag{16}$$

where $b = OA$, $g = AP$ and ϕ is the angle which line AP makes with the real axis. Differentiating Equation 16 with respect to time, and noting that $d\phi/dt = \omega_3$, we obtain **v**, the velocity of point P:

$$\mathbf{v} = ib\omega_2 e^{i\theta_2} + ig\omega_3 e^{i\phi} \tag{17}$$

The real and imaginary components are then

$$\left.\begin{aligned} R_v &= -b\omega_2 \sin\theta_2 - g\omega_3 \sin\phi \\ I_v &= b\omega_2 \cos\theta_2 + g\omega_3 \cos\phi \end{aligned}\right\} \tag{18}$$

Magnitude and direction of **v** are then found from Equations 7 and 8 by replacing s with v, **s** with **v**, R_s with R_v, and I_s with I_v.

Accelerations: We can next obtain a relationship

between the angular accelerations of the links. Differentiating Equation 11 with respect to time and denoting the angular accelerations as $d\omega_2/dt = \alpha_2$, $d\omega_3/dt = \alpha_3$, and $d\omega_4/dt = \alpha_4$, we have

$$(\omega_2^2 - i\alpha_2)be^{i\theta_3} + (\omega_3^2 - i\alpha_3)ce^{i\theta_3} + (\omega_4^2 - i\alpha_4)de^{i\theta_4} = 0$$

If we expand this equation in terms of its real and imaginary parts, we obtain two equations similar to Equation 12 and they can be solved for α_3 and α_4. Doing this, and substituting Equations 13 and 14 in the results,

$$\alpha_3 = \frac{\omega_3}{\omega_2}\alpha_2 - \frac{b\omega_2^2 \cos\delta + c\omega_3^2 \cos\varepsilon + d\omega_4^2}{c \sin\varepsilon} \qquad (19)$$

$$\alpha_4 = \frac{\omega_4}{\omega_2}\alpha_2 - \frac{b\omega_2^2 \cos\gamma + c\omega_3^2 + d\omega_4^2 \cos\varepsilon}{d \sin\varepsilon} \qquad (20)$$

Equations 19 and 20 give the angular accelerations of links 3 and 4, respectively, in terms of the known value of angular acceleration for link 2.

The linear acceleration of a point P on link 3 in Fig. 5 is obtained by differentiation of Equation 17 with respect to time. Denoting this acceleration as **a**,

$$\mathbf{a} = (-\omega_2^2 + i\alpha_2)be^{i\theta_2} + (-\omega_3^2 + i\alpha_3)ge^{i\phi} \qquad (21)$$

The real and imaginary parts are

$$R_a = -b(\omega_2^2 \cos\theta_2 + \alpha_2 \sin\theta_2) - g(\omega_3^2 \cos\phi + \alpha_3 \sin\phi)$$
$$I_a = -b(\omega_2^2 \sin\theta_2 - \alpha_2 \cos\theta_2) - g(\omega_3^2 \sin\phi + \alpha_3 \cos\phi) \qquad (22)$$

Magnitude and direction for **a** are then found from Equations 7 and 8 by replacing s with a, **s** with **a**, R_s with R_a, and I_s with I_a.

Slider Crank: A special case of the four-bar linkage is the slider-crank mechanism shown in Fig. 6. That is, θ_4 = constant = $3\pi/2$, $d = \infty$, and thus $\omega_4 = \alpha_4 = 0$. It is to be noted that the general case of a slider crank is illustrated. That is, the line of motion of the slider does not pass through the crankshaft. Equations 13 and 19 give the angular velocity and acceleration, respectively, of the connecting rod, regardless of whether the line of piston travel does or does not pass through point O.

Example: In Fig. 7*a* the center line of the cam is at 45 deg to line OD. The angular velocity of the cam is 5 rad per sec counterclockwise and its angular acceleration is 2.5 rad per sec² clockwise. Angular velocity and acceleration of the follower are to be found.

SOLUTION: An equivalent* four-bar linkage is shown in Fig. 7*b*. Thus $\theta_2 = 315$ deg $= 5.4978$ rad, $\omega_2 = 5$ rad per sec and $\alpha_2 = -2.5$ rad per sec². Dimensions are $a = 7$ in., $b = 2.656$ in., $c = 5.438$ in., and $d = 7.500$ in. Velocity ω_4 and acceleration α_4 are to be found.

Substituting into Equations 1 through 6,

$$l = [7^2 + 2.656^2 - 2(7)(2.656)(0.7071)]^{1/2} = 5.456 \text{ in.}$$

$$\beta = \sin^{-1}\left[\frac{2.656}{5.456}(-0.7071)\right] = 0.3514 \text{ rad}$$

$$\psi = \cos^{-1}\left[\frac{5.438^2 + 5.456^2 - 7.500^2}{2(5.438)(5.456)}\right] = 1.5186 \text{ rad}$$

$$\theta_3 = 1.5186 + 0.3514 = 1.8700 \text{ rad}$$

$$\lambda = \sin^{-1}\left[\frac{5.438}{7.500}(0.9986)\right] = 0.8077 \text{ rad}$$

$$\theta_4 = 2\pi - 0.8077 + 0.3514 = 5.8269 \text{ rad}$$

From Equation 15,

$$\delta = 5.4978 - 5.8269 = -0.3291 \text{ rad}$$
$$\varepsilon = 1.8700 - 5.8269 = -3.9569 \text{ rad}$$
$$\gamma = 5.4978 - 1.8700 = 3.6278 \text{ rad}$$

Substituting into Equations 13 and 14,

$$\omega_3 = -\frac{2.656(-0.3232)(5)}{5.438(0.7280)} = 1.084 \text{ rad per sec}$$

$$\omega_4 = \frac{2.656(-0.4673)(5)}{7.500(0.7280)} = -1.136 \text{ rad per sec}$$

Since the result has a minus sign, ω_4 is clockwise. Substituting into Equation 20, we obtain the angular acceleration of the follower:

$$\alpha_4 = \frac{-1.1365}{5}(-2.5) + \frac{2.656(25)(-0.8841) + 5.438(1.1753)}{7.500(0.7280)} + \frac{7.500(1.2916)(-0.6856)}{7.500(0.7280)}$$
$$= 0.5682 - 10.7974 = -10.229 \text{ rad per sec}^2$$

The minus sign indicates that α_4 is clockwise.

*R. T. Hinkle—*Kinematics of Machines*, Prentice-Hall Inc., New York, 1953, pp. 71-72.

A Mechanisms Conference Paper

This article was presented as a paper at the Fourth Conference on Mechanisms, Purdue University, October 14-15, 1957. These Conferences are cosponsored by the Purdue School of Mechanical Engineering and *Machine Design*.

They Say . . .

"The conduct of applied research has been compared to the performance of a symphony orchestra. At times the score calls for a single instrument to perform in solo, but generally a greater variety of instruments is required for richer, fuller results. With the complex score of today's problems, the technique of a single science may be effective on some occasions, while on others several acting in concert produce the most favorable results."—E. FINLEY CARTER, *director, Stanford Research Institute.*

Fundamentals of design, operation, and application of pressure elements for industrial instruments.

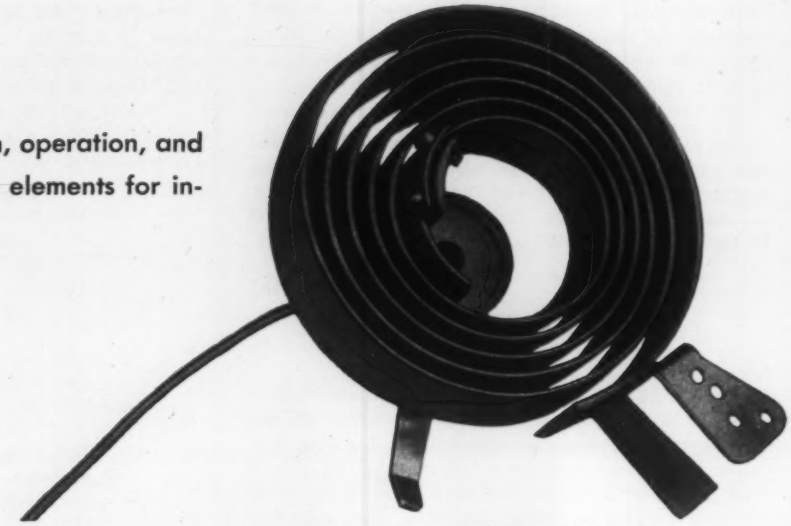


Fig. 1—Spiral pressure element. These elements are more sensitive than simple Bourdon tubes. End movement is ample for direct connection to gage pen or pointer

Pressure Gage Elements

PRESSURE gages are built for specific ranges of pressures and for varying conditions of operation. For maximum efficiency and service, engineers should be familiar with the design and operation of the different types of instruments at their disposal.

Pressure elements used most widely in industry today are:

1. Bourdon tube.
2. Spiral and helix.
3. Spring and bellows.
4. Absolute-pressure bellows.
5. Bell gage.

Bourdon Tube: This element is a thin-walled tube, flattened to an elliptical cross-section and bent into an arc. One end of the tube is closed and free to move. The other end is open and attached to the pressure source.

With pressure in the tube, the arc tends to straighten. Because this motion is usually slight, a sector-and-pinion gear is used to amplify it enough to move a pen or pointer across a graduated scale. A straight-line calibration can be obtained for the free-end movement of the tube which permits equal graduations on the dial. The tube must be designed to get maximum movement per unit change in pressure and to resist permanent deformation.

The metal or alloy used for the tube and the method of heat treatment are of extreme importance. The best materials for Bourdon tubes are phosphor bronze, beryllium copper, stainless steel, and chrome-alloy steels.

From the standpoint of design, the same sector-and-pinion should give the same full-scale pointer travel regardless of pressure range. This requires a constant end movement of the tube for various ranges, and is achieved by selecting the proper material and best wall thickness for the range.

In all cases, movement of the tube is relatively small and generally prevents the use of this element for narrow pressure spans or for lower pressure ranges.

Spiral and Helix: Both the spiral and the helix pressure elements are Bourdon tubes wound as a flat spiral, Fig. 1, or as a helix of several turns. These elements are much more sensitive than the simple Bourdon tube. The spiral or helix shape gives the effect of the sum of a number of Bourdon tubes, which results in greater movement of the free end for a given pressure change.

It is not necessary to amplify end movement with a sector-and-pinion as in the Bourdon tube. The spiral and helix elements have ample end movement for most purposes, and can be connected directly to the pen or pointer by a simple link. This has led to the almost universal use of the spiral or helix for pressures ranging from about 10 to 4000 psi. If amplification is needed,

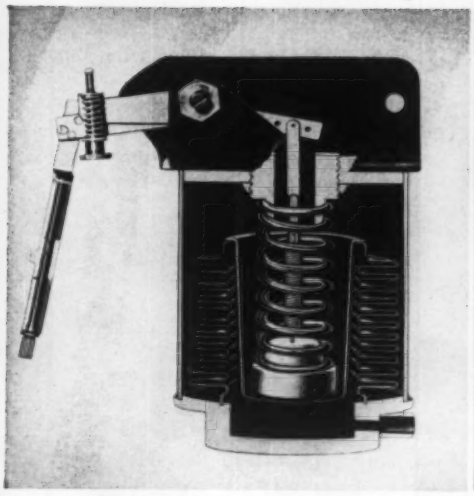


Fig. 2—Intermediate range spring-and-bellows element. Movement of the bellows upward against the spring is transmitted through suitable linkage to a pen or pointer

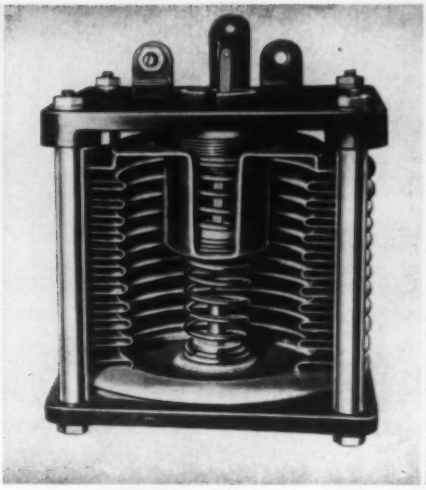


Fig. 3—Low-pressure element. This unit develops up to 25 times the power of a spiral element for the same pressure change. Readings are accurate even at low pressures because of high force at the pen or pointer

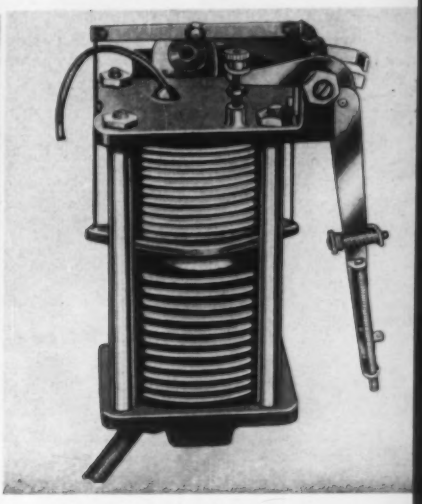


Fig. 4—Absolute-pressure element. This dual spring-and-bellows unit corrects automatically for variations in barometric pressure

By R. J. CHURCH
Industrial Div.
Minneapolis-Honeywell Regulator Co.
Philadelphia, Pa.

it can be produced by increasing the length of the pen or pointer arm.

Accuracy of the spiral type instrument can be held within ±1.0 per cent of full scale. This degree of accuracy is usually adequate for industrial pressure measurement and control.

Spring and Bellows: The spring-opposed bellows unit is used for pressures with full-scale values between 100 in. of water and 15 psi, or for vacuums with full scale values between 10 and 30 in. of mercury.

The intermediate-range type, Fig. 2, is a spring-loaded metal bellows enclosed in a shell connected to the pressure source. Pressure compresses the bellows and forces its lower end upward against the opposing force of the spring. A rod transmits this vertical movement through suitable linkage to the pen or pointer.

The low-pressure element, Fig. 3, is designed for pressures of 5 to 75 in. of water, and for vacuums with a full-scale range of 50 in. of water. The bellows is relatively large, and pressure is introduced internally. This creates a much greater force against the opposing spring per unit of pressure change. To measure vacuums, or combinations of vacuum and pressure, the gage has an additional spring which opposes the collapsing of the bellows caused by the vacuum.

Spring-and-bellows elements are very sensitive. The low-pressure type develops as much as 25 times the power of a spiral element for the same pressure change. With forces of this magnitude, power at the pen is high. It is not necessary to tap the instrument to get an accurate reading even at low pressure.

Calibration of a pressure gage depends upon a carefully designed, heat-treated spring which is permanent in its gradient. Bellows gradient is small compared with that of the spring, and has little effect on calibration of the unit since the bellows serves principally as a pressure enclosure.

Pressure ranges can be changed simply by replacing the spring when measuring positive pressures. In the low-pressure element, both upper and lower springs are used, and an entirely new element must be installed if it is necessary to change the range.

Absolute-Pressure Bellows: In many applications it is necessary to compensate for variations in barometric pressure. Although it is possible to compensate by reading the barometer periodically and resetting the zero or set point of the controller accordingly, it is much better to have a unit which will correct automatically. The absolute-pressure spring and bellows element does this, Fig. 4.

In this unit, a yoke connects two bellows in series to the pen shaft. The upper bellows, which contains the actuating spring, is evacuated to a fraction of a millimeter of mercury pressure absolute. The lower bellows is not evacuated and is connected to the source of pressure to be measured.

As pressure decreases within the lower bellows, resultant upward force is decreased, and the spring causes the lower bellows to collapse. This movement is transmitted through the lever arm to the pen.

Since barometric pressure is the same on both bellows, the unit corrects automatically. An increase in barometric pressure causes the lower bellows to collapse slightly. The same pressure change acts on the upper bellows causing it to collapse the same amount. Barometric-pressure changes cannot move the pen.

Bell Gage: These gages are used to measure slight vacuums and pressures in the range of 1 in. of water. The actuating element of these gages consists of two bells suspended from opposite ends of a balance beam and immersed in a tank containing oil of a certain viscosity. The measured-pressure line terminates beneath one bell, with its opening extended above the oil level.

Where it is necessary to correct for ambient-pressure differences between instrument and process, compensating lines in the system eliminate errors in measurement.

From "Pressure Gage Elements," presented in the Minneapolis-Honeywell Regulator Co. Publication, Instrumentation, *Volume* 10, *No.* 6.

Characteristics of

Power Rectifiers

By R. M. CRENSHAW and A. L. MUNN, General Electric Co., San Francisco, Calif.

THE term "semiconductor" is generally applied to rectifiers of the metallic type as contrasted with mercury arc or vacuum-tube rectifiers. The semiconductor family consists of four important types: Copper oxide, selenium, germanium, and silicon. In industry, germanium and silicon rectifiers are perhaps the most important of the semiconductor family. Dc voltage adjustment of semiconductor rectifiers is preferably obtained by changing applied ac voltage with induction regulators. Saturable reactors may also be used but are less desirable because of poor power factor. By contrast, the mercury arc rectifier uses a combination of ac supply change and modest phase control to obtain dc output adjustment.

Germanium Rectifiers: The germanium power supply was originally offered for 65 v, dc output. High current-density of the cells permitted a very high current rating in a small package as compared to selenium rectifiers. Because of the high-voltage rating of an individual germanium rectifier, loads encountered in industrial processes are natural because they are easily adaptable to a power supply within the voltage rating of a single germanium cell. Individual cells may be paralleled or several bridge circuits may be connected in parallel to provide almost unlimited load current ratings.

Outstanding advantages of the germanium rectifier are:

1. High peak inverse-voltage rating.
2. High efficiency.
3. Good voltage regulation because of small voltage drop per cell.
4. Stable characteristics, not subject to aging as with selenium.
5. Compact design because of high current-density.

The most rewarding application of germanium is in the range of 20 to 400 v. It offers excellent efficiency at these voltages, so the inherent safety of lower cell-line voltage can be obtained without penalty. When germanium-rectifier equipment is operated at its voltage rating for a given series cell arrangement, an efficiency of 92 to 96 per cent can be obtained.

Mercury-arc rectifier efficiency is excellent at 500 v and higher, but efficiency decreases as operating voltage is reduced. The rectifier is efficient where high voltage is required and is used extensively to supply rotating drives at high voltages. Table 1 compares characteristics of power rectifiers.

Table 1—Characteristics of Power Rectifiers

Factor	Rectifier		
	Germanium	Mechanical	Mercury-Arc
Space	More than mercury-arc	Less than mercury-arc	——
Reliability	Good	Least dependable	Best
Maintenance	Simple	Complex	Simple
Operation	Simple, no attendance	Complex, training required	Simple, no attendance
Failure Correction	Replace cell and fuse	Dress or replace contacts	Replace small tubes
Voltage Sensitivity	Not sensitive	Very sensitive	Not sensitive
Service Interruption, Arc Back	None	Frequent	None
Arc-Back Protection	Fuse	Short-circuit switch	Anode breaker
Overload Capacity	Definite limit, damaged if exceeded	Definite limit, damaged if exceeded	Very high, no damage if exceeded
Over-Voltage Capacity	Definite limit, damaged if exceeded	Definite limit, damaged if exceeded	Very high, no damage if exceeded
Over-Temperature Capacity	Inherent limit	Not too sensitive	Broad range
Environmental Sensitivity	Limited by switchgear devices, sealed	Contacts sensitive to air	Limited by switchgear devices, sealed
Starting	Instantaneous	Time warmup	Time warmup
Voltage Adjustment by Phase Control	No	Yes	No
Power Factor	95	92 to 98	98
Efficiency	95 to 96	96 to 97	85 to 96

Silicon Rectifiers: The silicon rectifier has some attractive characteristics. Maximum continuous operating junction temperature for ger-

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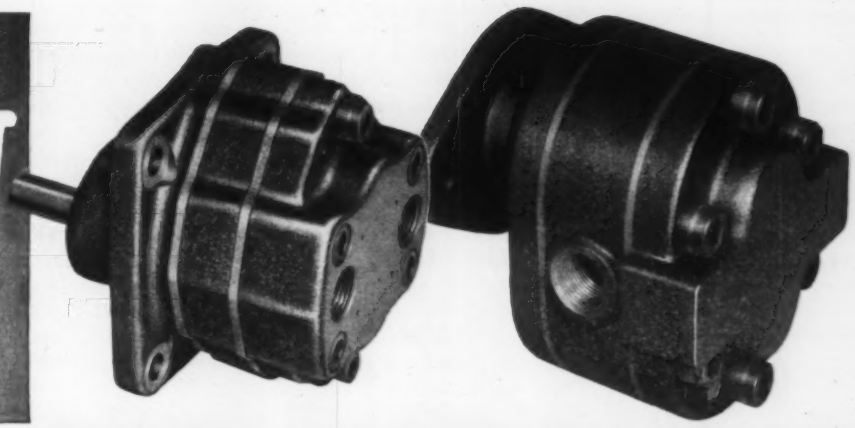

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The compact design of these units saves space and simplifies installation problems. They can be provided for either flange or foot mounting and with either side or rear ports as standard (front porting is available on special order). POWERMAX pumps or motors may be supplied with a built-in relief valve if desired.

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For applications such as power steering where two pumps of substantially different operating characteristics are required, POWERMAX pumps may be furnished in duplex or tandem models, with both units mounted on a single shaft. This allows substantial savings through the elimination of a second driving source, reductions in hydraulic piping, and lower installation costs.

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Circle 480 on Page 19

manium high-current cells is approximately 65 C. These thermal limitations are safely below the melting points of the various metals used in the cells. Germanium melts slightly below 1000 C, while silicon melts at 1400 to 1500 C. Alloying metals required to produce the semiconductor characteristics have much lower melting points but are still safely above the range of operating-temperature values.

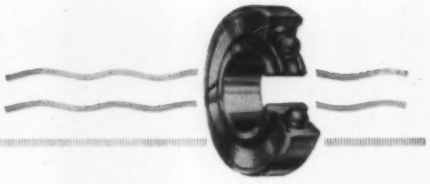
The higher operating temperature of silicon simplifies design and reduces cost of cooling. Another important feature is the ability of silicon to block high inverse voltages. It also has good inverse-voltage temperature characteristics. Although the forward voltage drop of a silicon cell is about 1¾ times that of germanium, ability of silicon to operate at a higher voltage offsets this disadvantage. When operating at their respective rated voltages, each type of rectifier cell shows approximately the same efficiency. High-current silicon rectifier cells are now available in production quantities.

At present, silicon is particularly useful in the range of 100 to 850 v, particularly where ambient temperatures of 40 C and higher may be encountered. The high-current silicon cell, when used in equipment employing the three-phase bridge circuit, will deliver 150 v dc as compared to 75 v for germanium. The current rating is in the same range as the germanium cell, however. Exact rating is governed by the temperature of the stud on which the cell is mounted.

Cell Cooling: Both germanium and silicon present the same problems with respect to cooling, although silicon can be operated in a considerably higher ambient temperature and still retain its high current-capacity. Some type of forced cooling is necessary for both types to obtain the advantages of extremely high current-density. The direct-water-cooled method is now in general use for large-capacity equipment where output voltage does not exceed 150 v. Air-cooled units are available for higher ratings.

From a paper entitled "Semiconductor Rectifiers—Present and Future—For Electrochemical Loads," presented at the American Institute of Electrical Engineers Winter General Meeting in New York, February, 1958.

Causes of Bearing Failure



By **CARL L. DELLINGER**, Norma-Hoffman Bearings Corp., Stamford, Conn.

Analysis of bearing failures in small electric motors has revealed five conditions of loads and/or vibrations which can adversely affect bearing life. Some of these conditions are applicable to other devices such as gearmotors and speed reducers which are also subject to bearing failures

PINIONS, in a plain spur or a helical drive, impose an overhung load on motor bearings. However, this is not the only load transmitted to the bearings. Tooth inaccuracies of the driving pinion and driven gear result in an additional pulsating or vibratory load. The worst condition occurs when these inaccuracies are on the pinion, for the additional load always acts on one portion of the bearing inner ring, the inherently weakest member. Lack of concentricity between pinion and bearings also causes an additional load on one portion of the bearing inner ring. The best way to minimize this condition is to make the pinion an integral part of the motor shaft. Misalignment, either initial or running, and radial displacement of gear centers, can also cause loads which reduce bearing life. Reduced tolerances on the mating surfaces which locate the motor and gear box help to minimize bearing loads.

Spline drives theoretically do not impose any load on motor bearings and, therefore, they permit use of relatively smaller bearings. However, lack of concentricity, and running and initial misalignment impose relatively large loads on these bearings. An integral spline cut on the shaft, and careful adherence to close tolerances on locating surfaces extend bearing life considerably. Planet systems, although generally balanced, are susceptible to tooth inaccuracies, lack of concentricity, and misalignment. A radial or angular displacement of the planets causes system unbalance which in turn overloads the bearings.

Armatures: The weight of the armature carried by its bearings represents the only other tangible load that can be easily related to the bearings. A slight dynamic unbalance can result in considerable additional bearing load. This is an especially important consideration in small motors where bearings are light and speed is high. Shaft deflection at higher speeds can add even more load to initial unbalance. Much of this can be eliminated by a careful consideration of critical speeds, a thorough static and dynamic balancing with motor bearings in position, and selection of a balancing speed as close to the actual designed running speed as is economically possible.

Potential trouble also exists in the form of radial magnetic forces which are the result of a radial displacement of the armature from the center of the stator field. Preliminary studies under a locked-rotor condition indicate that these forces are quite large with a relatively small radial displacement. Frequency of these forces is a multiple of input electrical frequency and depends on the type of harmonic patterns encountered. A high degree of concentricity must be maintained between all mating surfaces of the

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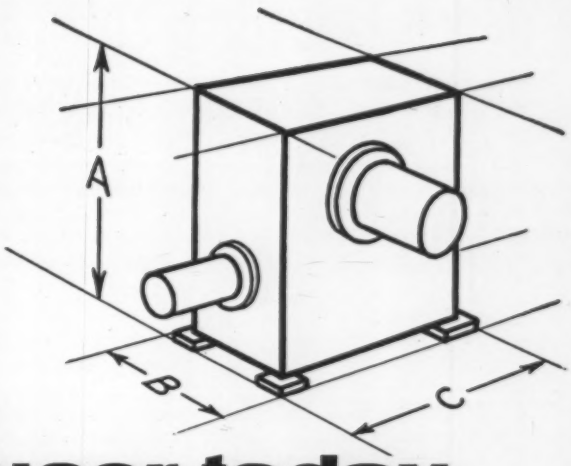

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By George, design it yourself and it'll fit. How? Well, you know your size limits. Draw the biggest box that'll fit the space and you've got your reducer housing specifications.

Now you need gears that will (1) transmit the needed horsepower under all operating conditions, (2) provide the ratio your machine requires and (3) fit the space that's available. You'll soon discover that there are limits to what gears can do in transmitting horsepower. The cheapest answer is parallel shaft helical gears. If they'll fit you're in clover. But they take the most room, especially when you're out of the fractional hp range. The right angle worm and gear combination is the most compact drive arrangement.

Here again you have a choice. Cylindrical worm gearing is often used, and if it'll do the job, is worth consideration. But it's not the most compact possibility. The best way to shrink gears and still carry the load is the double-enveloping worm gear design. Both worm and gear are throated and the two literally wrap around each other. This brings center distance of the two shafts closer together and you can put them inside smaller housings.

Does this reduce load capacity? No sir! You can carry the same load with center distances up to 33% smaller than those of cylindrical worm gears. Or use the same center distance and carry a greater load. Will these gears hold up in operation? Sure, if you beef up the teeth, the bearings and the housing. Use straight-sided worm and gear teeth and you'll get all the strength there you'll ever need. Use large taper roller bearings with real B-10 life. Use a reinforced, heavy wall housing that won't distort under load. Put fins on it for added cooling and increased thermal horsepower capacity to meet your needs. Now, put the whole thing together and you've got a speed reducer that's a dilly.

Designing your own speed reducer give you a headache? Looking for an easier way? There is one. Someone's already done exactly what you're talking about. You can order that compact speed reducer right off the shelf. Where?

Cone-Drive Gears, that's where!

Yes sir. They stock double-enveloping worm gear speed reducers from fractional to 665 hp. Standard ratios from 5:1 to 70:1 in about 15 increments, all interchangeable in any type housing of a given center distance. Worms over and worms under. Gear shafts vertical, too. Single- or double-extended output shafts, or shaft mounted. Over 200,000 combinations possible. Wow! Just about anything you want.

Better get Cone-Drive's new speed reducer catalog that details everything. Ask for Bulletin CD-218. Cone-Drive Gears, Div. Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

stator, bracket, and bearing seat to minimize these forces.

Misalignment of the bearing inner ring, regardless of cause, can result in severe internal loading of the bearings. On the other hand, if the shaft shoulder is too large in diameter, there is some danger of fouling the sealing plates in the bearings. This possibility is increased when bearings are subjected to heavy thrust loads. Careful bearing seating will minimize this danger.

Temperature rise of the armature results in a differential temperature between the bearing inner and outer rings, and causes a serious radial preload condition in the bearing which shortens its life. Proper air circulation within the motor or additional clearance within the bearing usually remedies the possibility of radial preload.

Though it should not be considered as a load, rapid acceleration of a motor can be quite harmful to a bearing. It is the unusual combination of a practically no-load condition coupled with a high acceleration or deceleration which induces skidding in a bearing, thereby shortening its life.

Stators: Bearing outer-ring misalignment is probably one of the most common sources of bearing trouble in small motors. It can be caused by a radial displacement of the two bearing-housing bores in the end brackets or by cocking either end bracket. It can also be caused by axial run-out of the locating shoulders of the stator, end bracket, or bearing housing shoulder, or by a distortion of the main stator or end brackets initially or from high temperature. The higher the operating temperature, the greater this possibility. Not only can misalignment occur as a result of the geometry of the motor, but it can also be the result of a secondary deflection caused by a deflection in the motor-support brackets.

External Vibration: There is evidence that vibration can cause excessive bleeding and breakdown of grease, thereby decreasing its useful life. Vibration may also cause a slumping of grease which causes it to be churned excessively by the rolling elements within the bearing. There is little doubt that up to 450 F these effects tend to shorten bearing life. However, at 600 F, where most fluids used for lubrication evaporate quite rapidly, excessive bleeding and even churning of the grease may tend to insure a sufficient amount of lubricant in the load zone as long as this fluid remains in the bearing. If true, this would certainly suggest the use of a wide bearing with an additional available volume for grease and a greater percentage of grease within the available bearing void.

External Forces: Rapid acceleration, and sometimes deceleration, of elements on which motors are mounted induces a force on the motor bearings equal to the mass of the rotor times acceleration. An even heavier load can be imposed upon the bearings by angular motions. The precession rate of this movement dictates the resulting gyroscopic couple that will have to be resisted by the motor bearings. The higher the motor speed and the shorter the bearing spacing, the greater the bearing load.

From a paper entitled, "Effect of Loading Systems and Vibration on Bearing Life," presented at the SAE Annual Meeting in Detroit, Mich., January, 1958.

Characteristics and Applications of

Proximity Switches

By **F. A. MANNERS**, Electric Controller & Mfg. Div., and
R. C. MIERENDORF, Engineering Electronic Control Mgr., Square D Co., Milwaukee, Wis.

THE complexity of a machine function and the intimate relationship between machine and control make it essential that control systems be designed as carefully correlated combinations of sensing, logic, and output elements, and with the end requirements of the final operation in mind at all times.

Results of a study of machine-system input problems indicate that co-ordinating (logic) and output elements such as relays and starters are responsible for only approximately 10 per cent of system failures. Most problems are traceable to input devices and purely mechanical difficulties. Even with simple control systems, many problems arise from misapplication of conventional sensing devices. Many difficult and previously "impossible" applications can be handled satisfactorily by use of proximity inputs. Because of its characteristics and capabilities, proximity inputs offer means of rendering a control system more reliable, more compact, and less expensive to build and maintain.

Proximity Limit Switches: One particular system application incorporates a switch which is activated by the approach of magnetic material. The sensing element is shown in Fig. 1. Presence of magnetic material near the pick-up end causes a change in phase and amplitude of the signal. In this system, signal voltages are very low, and driving coils operate at less than 6 v rms. It is possible to couple the sensing element to the control panel with a cable to 50 ft in length. This length is determined mainly by drop in voltage to the driving coils. In certain cases, cable length may be increased by raising the voltage to compensate for cable voltage drop. The control panel receives the signal, amplifies it, and conveys it to a phase-shift detector. The detector converts the analog change to a digital signal which operates a relay to a static switch or

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ACP ALODINE* — its properties and functions in protecting aluminum alloys and bonding paint to them

By ALFRED DOUTY: Technical Director, AMERICAN CHEMICAL PAINT COMPANY

Aluminum protects itself against corrosion by a coating of its own oxide. This adds weight, but does not provide complete protection. Even commercially pure aluminum in clean air at ordinary room temperature oxidizes indefinitely.

The use of adherent inorganic protective coatings on aluminum has long been recognized as efficacious in reducing corrosion rate and prolonging paint life. Since aluminum oxide tends to be protective, it is natural that the most intensive early efforts in this direction should have involved processes for improving the properties of the naturally occurring oxide coating. Anodizing, or electrochemical oxidation, although it is one of the most effective of such methods, is rather costly and time consuming.

ALODINE†

Early in 1945 a new chemical process was devised for producing an amorphous phosphate coating on aluminum. Its simplicity, speed and economy and the unique properties of the coating have resulted in wide commercial acceptance. It is called the Alodine Process.

Some idea of the effectiveness of the Alodine coating on unpainted 3S Grade aluminum may be had from Fig. 1. All panels were removed from the salt spray cabinet after 300 hr. except the Alodized and anodized panels, which were continued to 800 hr.

Organic protective and decorative coatings, such as paint, likewise require a corrosion-retarding undercoating of the kind produced by Alodine to achieve their maximum life and adhesion.

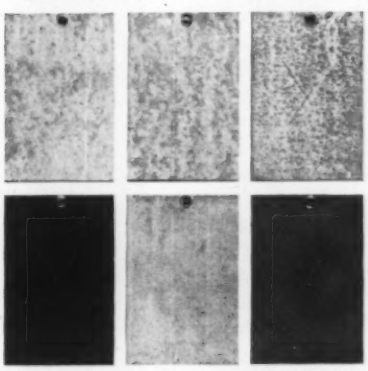

Fig. 1. Salt spray test comparison of Alodine with other surface treatments on unpainted aluminum. (Left to right, top row) solvent wiped —300 hr.; alkali cleaned—300 hr.; phosphate coated—300 hr. (Bottom row) chemically oxidized—300 hr.; anodically oxidized—800 hr.; Alodized—800 hr.

The effect of the Alodine coating in retarding underpaint corrosion is shown in Fig. 2. The Alodized panel was given a top coat only. All other panels in the series were primed after the surface treatments with a regular automotive product, baked, given a surface coat dry-scuffed with sandpaper as per standard automotive practice, and then finished with a regular black baked top coat. The panels were removed from the salt spray after failure of the paint film had set in.

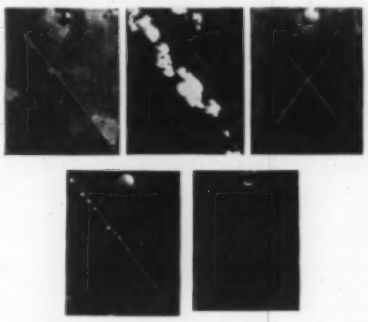

Fig. 2. Salt spray test comparison of Alodine with other surface treatments in retarding underpaint corrosion. (Left to right, top row) alkali cleaned and phosphoric acid dipped—300 hr.; phosphoric acid, solvent cleaned—300 hr.; zinc phosphate coated—400 hr. (Bottom row) anodically oxidized—3000 hr.; Alodized—3000 hr.

COATING CHARACTERISTICS

The coating produced by this new process is an amorphous metallic phosphate, dense, rather hard, and apparently nonporous. Unlike most oxide films, it is nonabsorptive and cannot be dyed or stained. Sealing in hot water or salts has no apparent effect. It differs markedly in appearance from previously known phosphate coatings, as shown in Fig. 3.

Electrical Resistance. Very little information is available at the present time on the electrical properties of the coating, but it is known that resistance increases very rapidly with thickness and as a result coatings normally produced offer extremely high resistance.

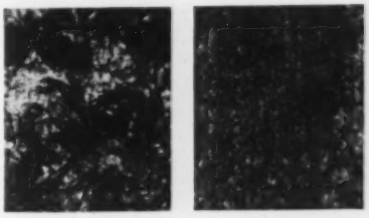

Fig. 3. (Left) conventional phosphate coating on aluminum; (right) Alodine coating produced in 3-min. immersion, rinsed and air dried. Magnification 500 diam.

Weight and thickness. Generally speaking, the weight of the amorphous phosphate coating increases with processing time, bath strength, and bath temperature. It is interesting to note that the increase becomes less and less pronounced as the temperature increases and actually reverses itself into a sharp decline between 130 and 140°F.

Adhesion. The original purpose in development of this process was to improve adhesion of the paint to aluminum surfaces and thus lengthen their overall life. Only later was it discovered that the film itself provides corrosion resistance.

Resistance to Bimetallic Corrosion. Since it has very high surface resistance, the coating, as would be expected, offers good resistance to bimetallic or galvanic corrosion. Test samples are available to illustrate the insulating effects.

We present here a general and by no means complete, report on ACP Alodine—its properties and uses in protecting aluminum alloys. Your ACP sales representative can give you a much fuller story. Or write us at Ambler.

*Alodine is a registered trademark of American Chemical Paint Co.

†Since the introduction of Alodine amorphous phosphate coatings, ACP has developed a complete line of Alodine amorphous chromate coatings for superior corrosion resistance.

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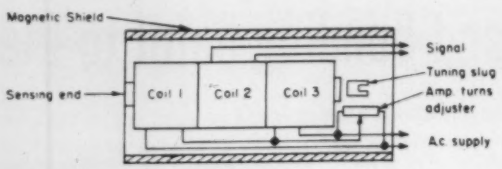


Fig. 1—Sensing element or transducer consisting of two driving coils and a pickup coil. The undisturbed output signal may be preset with respect to amplitude and phase

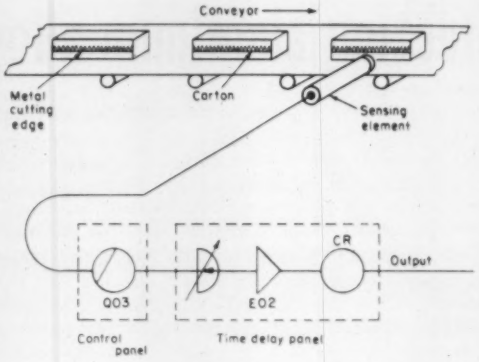
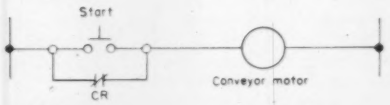


Fig. 2—Early application of proximity switch as an inspection device. Conventional mechanical limit switches and photoelectric devices proved inadequate for this particular operation. The switch operates at high speed on lightweight cartons and controls the conveyor drive motor



other static switching logic element.

A thyratron may be used as a phase-shift detector in which an undisturbed grid signal normally holds the thyratron in a nonconducting state. Presence of magnetic material at the sensing end of the transducer causes the grid signal to lag, which triggers the thyratron at the leading edge of its anode voltage. The thyratron then gives a full half cycle of output which has sufficient power to drive a relay or pulsing transformer.

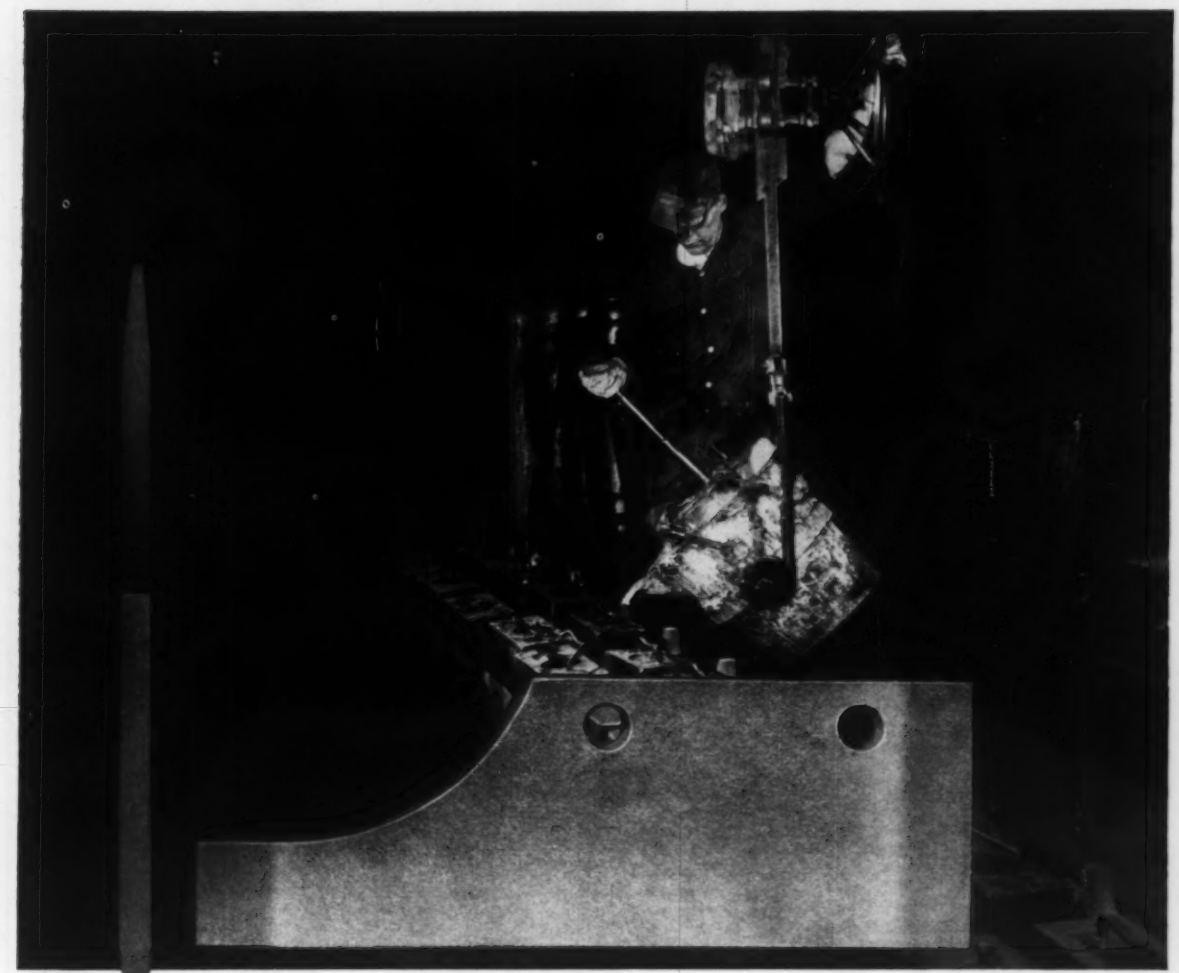
A second mode of operation is possible by special tuning of the sensing element, allowing a leading phase shift to occur when the transducer is disturbed. Here, the thyratron is continuously conducting and providing an output. When the disturbance occurs, the grid signal is phased ahead, thus cutting off the thyratron and effecting a control function. Useful system circuit designs can be accomplished by combinations of these two modes of operation. When two transducers of the Off-On type are used with one control panel, the primitive logic function OR is the result. An adaptor accessory, into which two transducers are plugged, is available for a standard control panel. Thus, when it is necessary to have control responsive to either one of two separate machine functions, the control panel provides the primitive logic without additional components.

Applications: An interesting early use of the proximity switch involved an application in which it was literally impossible to use conventional mechanical limit switches or other forms of detectors such as photoelectric cells. Requirement was for an inspection device for cardboard cartons used to dispense metal foil or waxed paper. The proximity switch inspected each carton to insure presence of the metal cutting edge before final packaging, Fig. 2. It had to operate at high speed on lightweight cartons and control a solenoid valve or conveyor drive motor. It monitored each carton and tripped an electronic time delay unit as each passed. The time delay was set so that it would not be tripped during the interval between cartons but would trip whenever a carton passed lacking the cutting strip. In this application, a control relay was operated by the time-delay unit to control the conveyor.

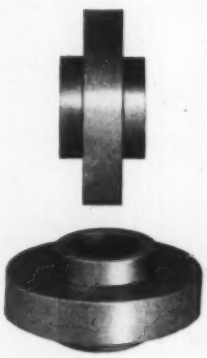
Another example of the versatility of this basic design involved a simple positioning device. It was to have a control which would operate a conventional ac motor either forward or reverse through appropriate relays depending upon the position of a boom with respect to a metal work surface. A sensing device was adjusted to a null position at a given distance from the metal work surface. As the distance from the surface increased, the output signal operated a phase detector which picked up a relay to cause the motor to drive the boom closer to the work surface. Conversely, when the distance from the work surface decreased, a second phase detector working on opposite polarity picked up a second relay to reverse the motor to drive the boom in the opposite direction. A sensitivity control provided a tolerance on the operating distance such that no hunting would occur when the distance between the work surface and the boom remained within tolerance limits.

Numerous other applications of the proximity switch have been developed to monitor small metal parts in feeding chutes, or to control ejection of metal parts from dies before the following stroke of the press.

From a paper entitled "Proximity Switches—Characteristics, Design, and Application," presented at the AIEE Winter General Meeting in New York, February, 1958.



This customer SAVED TWICE with Ampco Shell Moldings



Gear blank shell-cast in Ampcoloy nickel bronze. Surface finish was held to ± .015. Only finishing required was to hob teeth and broach key-way. Savings were considerable.

In the wear strip above, shell-cast of Ampco Metal, all dimensions including end-bevels and hole locations were held to ±.015. The smooth surface finish required no machining. Substantial savings of time and money were realized.

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Ampco Shell Moldings are available in an extremely wide range of copper-base alloys. Ask an Ampco field engineer to tell you more about this money-saving production process. And write for Bulletin G36-957. *Ampco Metal, Inc., Dept. MD-4, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, Calif. — Southwest: Garland [Dallas County], Texas)*

G-16

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Centrifugal Pumps

"Data Required" guide for specifying corrosion-resistant centrifugal pumps tabulates data essential for successful solutions of pump problems. It also covers pump and system characteristics. Ampco Metal, Inc., 1745 S. 38th St., Milwaukee 46, Wis. K

Circle 601 on Page 19

Compression Sheath Connectors

The one-piece Uniring and the two-piece Hyring compression sheath connectors described in Bulletin YEC-7 are used for terminating, grounding, or tapping. They are available insulated or uninsulated and are color coded. Assembly procedures and typical installation tools are shown. 16 pages. Burndy Corp., Omaton Div., Norwalk, Conn. B

Circle 602 on Page 19

Industrial Models

"From the Mind of Man" is title of brochure which describes the services and facilities offered by this company in design, development, and fabrication of industrial models, mock-ups, and prototypes of wood, metal, or plastic. 8 pages. PDD Corp., 379 Market St., East Paterson, N. J. D

Circle 603 on Page 19

Antifriction Bearings

Design requirements for antifriction bearings of unusual shapes and sizes, and current information on suitable bearing component materials for high temperatures, corrosion resistance, and nonmagnetic properties are reviewed in Bulletin AFB-2. Case histories are illustrated. 24 pages. Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich. H

Circle 604 on Page 19

Metal Hose & Bellows

Bellows selection factors, application data, and available configurations are detailed in illustrated Catalog 172. Data are in table form. Various types of flexible metal hose for use with a number of liquids, gases, solids, and semisolids are also covered, along with couplings. 16 pages. Flexonics Corp., 1315 S. Third Ave., Maywood, Ill. J

Circle 605 on Page 19

Packings, Gaskets & Seals

Table listing effect of numerous gases, liquids, and solvents on packing, gasket, and sealing materials from metals to synthetics and leather, is found in illustrated Bulletin AD-162. Sections are devoted to static sealing, rotating and reciprocating service, and Teflon and Kel-F materials. 12 pages. Garlock Packing Co., 422 Main St., Palmyra, N. Y. F

Circle 606 on Page 19

Waveguide Components

More than 300 different types of microwave waveguide components, test equipment, and pressure windows are detailed in Catalog 58CP. Electrical operation, performance, and application data cover components in the 1.12 kmc to 90.0 kmc frequency range. 48 pages. Microwave Associates, Inc., Burlington, Mass. B

Circle 607 on Page 19

Carbon Steel Balls

Specifications, material analysis, accuracy, case depth, weight and package information relative to commercial-type carbon steel balls are included in Bulletin 102. Balls are made in 3/32 to 1 in. diameters. 4 pages. Hoover Ball & Bearing Co., Ann Arbor, Mich. H

Circle 608 on Page 19

Brazing Alloy

Engineering Data Sheet 21 concisely presents nominal composition, metallurgical properties, engineering properties, and application recommendations pertinent to Nicrobraz 150 high-temperature brazing alloy. Wall Colmonoy Corp., Stainless Processing Div., 19345 John R St., Detroit 3, Mich. H

Circle 609 on Page 19

Electric Motors

Application-engineered motors, their design factors, and a number of case histories are covered in illustrated Catalog P-86012. Included are submersible, jet pump, Uniseal, Submatic, Inst-O-Verse, gear, and self-lubricated motors. Specifications are given. 8 pages. Franklin Electric Co., Bluffton, Ind. J

Circle 610 on Page 19

Levers & Control Units

Levers and control units for trucks, buses, earth-moving machinery, hoists, pumps, and many other types of equipment are described and illustrated in detailed Bulletin HW-B3. Dimensional diagrams of various types are included. 16 pages. Batavia Metal Products Corp., Batavia, N. Y. F

Circle 611 on Page 19

Speed Reducers & Gears

Details on speed reducers, custom gears, and commercial gears are given in illustrated, wire-bound Catalog 80. Included are sizes, ranges, capacities, types available, schematic drawings, and specifications. Various speed reducer types have ratios up to 3660 to 1. 180 pages. Grant Gear Works, 154 W. Second St., Boston 27, Mass. B

Circle 612 on Page 19

Carbon & Graphite Brushes

Information on selecting the correct carbon or graphite brush for all types of rotating electrical machinery is contained in bulletin "Brushes for Electrical Rotating Machinery." Brush grade selection is tabulated by machine requirement. 12 pages. Speer Carbon Co., St. Marys, Pa. F

Circle 613 on Page 19

Plastic Panels

Bulletin 64 which describes Hetron flame-retardant, translucent polyester plastic panels is among descriptive data found in folder on this material. Technical and application data are included. Hooker Electrochemical Co., Durez Plastics Div., North Tonawanda, N. Y. F

Circle 614 on Page 19

Heavy Duty V-Belt

Condor LS V-belt for long-center, heavy duty drives is subject of Bulletin M210. Its proportioned construction eliminates belt whip and turn-over that leads to belt failure. 4 pages. Raybestos-Manhattan, Inc., Manhattan Rubber Div., Passaic, N. J. C

Circle 615 on Page 19

Copper & Copper Alloy

Current ASTM, SAE, AMS, Federal, and Military specifications relative to coppers, brasses, bronzes, and other copper alloys are listed in "Specifications Index" B-34. Nominal composition of Anaconda alloys is also given. 28 pages. American Brass Co., Waterbury 20, Conn. C

Circle 616 on Page 19

Milling Spindles

Milling spindles in standard models up to 50 hp and special models above that ratings are described in illustrated Catalog RT-38. All are hydraulically driven and feature constant horsepower over a variable speed range. Specifications and operating data are given. 12 pages. Romulus Tool & Engineering Co., 13581 Huron River Dr., Romulus, Mich. H

Circle 617 on Page 19

Pump Design

Radial loads, what causes them, how to measure them, and how their effects on Peerless process pumps are controlled are subjects of booklet "Mechanical Considerations in Pump Design." Formulas and diagrammatic explanations are presented. 8 pages. Food Machinery & Chemical

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Electric Slip Clutch Controls Reel Tension Automatically

Here are two ideas you might use to modernize machinery.

A manufacturer wanted to prevent pile-up at the let-off end and maintain constant tension on the take-up reel while processing conveyor belting on a 25 ft. platten press. Two features of Warner electric brakes and clutches—stepless torque modulation and electric operation—provided the simple answer to both problems.

First, an electric clutch was installed on the input shaft of the four-speed transmission for the take-up reel. (Fig. 1). Torque was adjusted so it slipped constantly, keeping tension on the roll and providing a soft, gradual pull-off.

Torque adjustable to reel speed

Since the take-up reel builds up in diameter during the winding cycle, it was necessary to vary reel speed and adjust clutch torque accordingly. A potentiometer was installed in the electrical circuit to increase or decrease current flow to the clutch and vary the amount of electromagnetic pull.

When starting up, the operator sets the transmission in first gear—its highest ratio. As the roll gets larger, he shifts to the next speed and adjusts the potentiometer, increasing clutch torque and reducing slippage. When the transmission reaches fourth gear, the reel is at its lowest speed and the clutch at its highest torque.

Fig. 1—Warner electric slip-duty clutch is mounted on input shaft of four-speed transmission. Power is transmitted when the clutch magnet is energized and attracts the armature.

Electric brake controls belt dip

The second problem was to prevent pile-up at the opposite end of the press. A Warner electric brake was installed on the jackshaft of the let-off reel. Intermittent engagement of the brake, actuated when the belt dips low enough to contact a micro-switch button, keeps slack under control. It's a simple way to prevent trouble when pulling material off a reel.

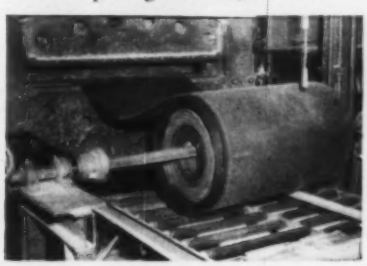


Fig. 3—72 in. conveyor belt press produces continuous rolls weighing up to nine tons.

New stationary-field clutches end slip-ring problems

Warner's new stationary-field electric clutch has integral leads to the field coil. Design is simple—only one stationary and two rotating members. The field is mounted to the machine frame, providing a permanent assembly of the electrical part. After extended usage, friction surfaces can be replaced without disturbing the electrical connections. Analysis of your machine drives, with electric brakes and clutches in mind, might reduce operating and maintenance costs appreciably.

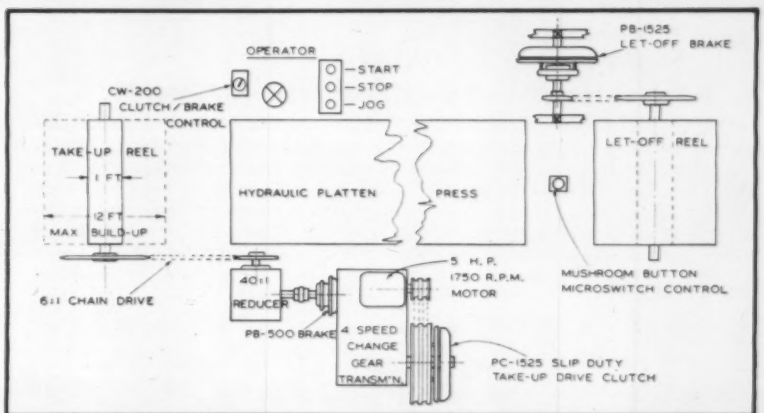
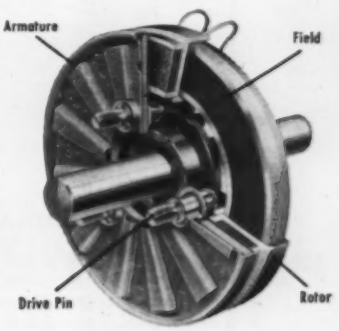


Fig. 2—Automatic tension control on power drive of take-up reel and intermittent braking of let-off reel make possible constant, equalized tension of material being processed. Mushroom button prevents excessive build-up at the let-off end.

Warner units do things other brakes and clutches can't do—so the opportunities to modernize are many!



Want more IDEAS?

Send for factual application sheets showing how to modernize by installing electric brakes and clutches on all types of machines, making them more productive, easier to control, simpler to maintain.

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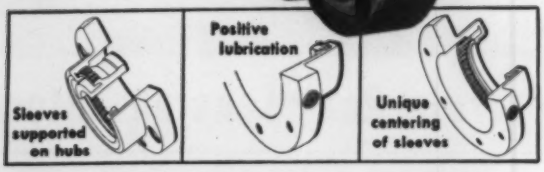
WARNER **ELECTRIC BRAKES AND CLUTCHES**

Circle 484 on Page 19

FAST'S Model B Coupling



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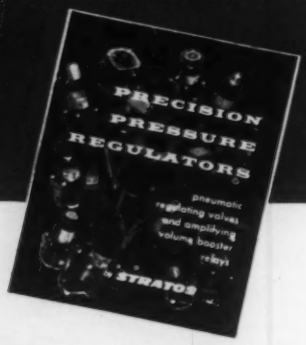

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Circle 486 on Page 19

Corp., Peerless Pump Div., 301 W. Avenue 26, Los Angeles 31, Calif. L

Circle 618 on Page 19

Gearmotors & Drives

Engineering Manual B-7223 on Moduline gearmotors and package motor reducer drives contains data on overhung load capacities, mounting limits, allowable thrust loads, dimensions, installation, and maintenance. Application data are included. 32 pages. Westinghouse Electric Corp., Gearing Div., Pittsburgh, Pa. F

Circle 619 on Page 19

Micaceous Insulation

Isomica-Epoxy micaceous insulation which combines Samica reconstituted mica with epoxy resin binders is subject of illustrated Technical Bulletin A-58. Its properties and characteristics, applications, and forms available are covered. 8 pages. Minnesota Mining & Mfg. Co., Mica Insulator Div., Schenectady 1, N. Y. B

Circle 620 on Page 19

Drive Chains & Sprockets

Illustrated Catalog A3 is a hard-cover book containing detailed information on a variety of drive and conveyor chain types, apron conveyors, sprockets, flexible couplings, and attachments. Specifications of each product, selection data, horsepower rating tables, dimensional drawings, and photos are among contents. 132 pages. Union Chain & Mfg. Co., Sandusky, Ohio. G

Circle 621 on Page 19

Miniature Ball Bearings

Miniature ball bearings used in instrumentation, aviation, and other industries are detailed in illustrated bulletin. Size range is from ⅜-in. OD down to 1/10-in. OD. Descriptive information on various standard types is included, along with application data. 24 pages. Miniature Precision Bearings, Inc., Keene, N. H. B

Circle 622 on Page 19

Pumps

Twin-Lobe rotary positive displacement pumps which draw in a new volume of material with each 180 degrees of rotation are described and illustrated in Bulletin TLP-57. They handle many liquids and soft solids. 12 pages. Manton-Gaulin Mfg. Co., Everett 49, Mass. B

Circle 623 on Page 19

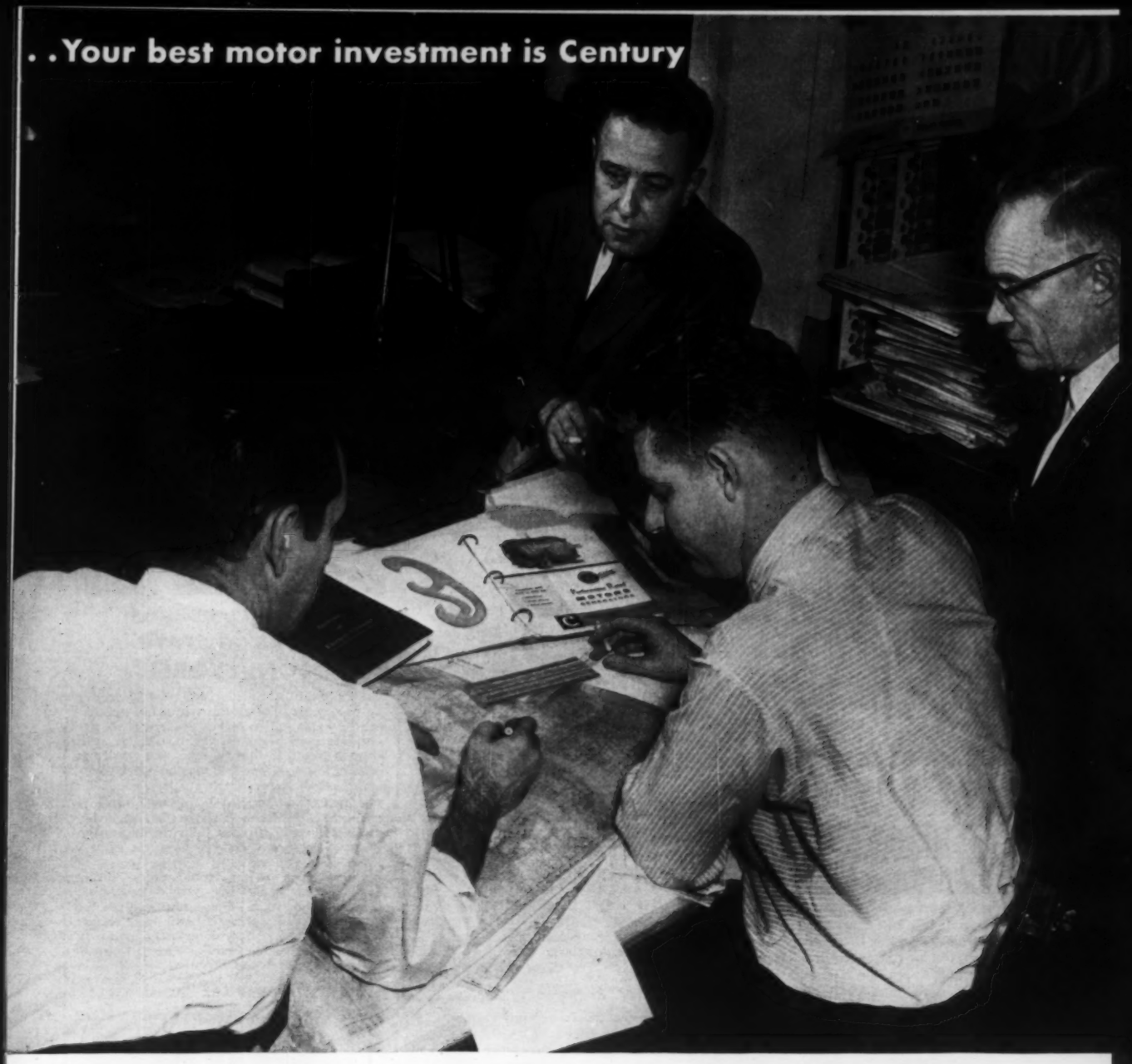
Variable Speed Systems

Typical installations for controlled automatic variable speed systems are described in Booklet F-1952. Uses include control of liquid level, pressure, rewind tension, speed sensitivity, load, temperature, and multiple drive conveyor. 8 pages. U. S. Electrical Motors Inc., Box 2058, Los Angeles 54, Calif. L

Circle 624 on Page 19

Castings

HTM pearlitic malleable iron for castings is described in illustrated booklet "The HTM Story." How it is made, its properties, chemical composition, and machinability are detailed. Photomicro-



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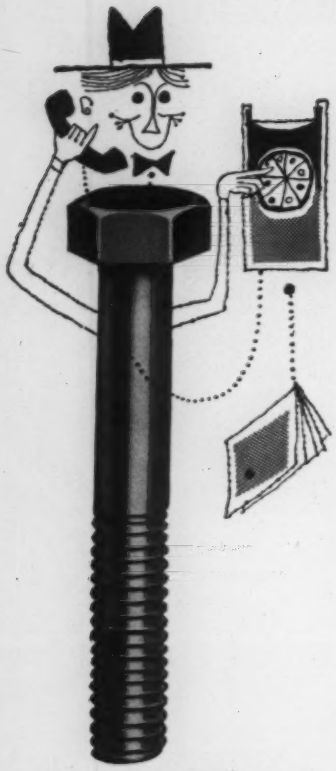

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Circle 488 on Page 19

graphs are included. 8 pages. National Malleable & Steel Castings Co., 10600 Quincy Ave., Cleveland 6, Ohio. G

Circle 625 on Page 19

Bearings, Bits & Steel

Illustrated "Timken Products" booklet outlines the design features of tapered roller bearings, along with their technical features. The various types are briefly described. Also covered are the forms of Timken alloy steel available and Timken removable rock bits. 36 pages. Timken Roller Bearing Co., Canton 6, Ohio. F

Circle 626 on Page 19

Hydraulic Governor

A parts list and installation and operating instructions relative to Type 4300 hydraulic governor are provided in Bulletin FP-1217. Unit is used to control generator sets, engine driven compressors, and arc welders and hoists. 4 pages. Farris Pickering Governor Co., 400 Commercial Ave., Palisades Park, N. J. D

Circle 627 on Page 19

Centrifugal Bronze Castings

Comprehensive discussion of the advantages of centrifugal casting of bronze and copper parts is given in brochure describing company facilities. Booklet covers the technique and shows all alloys available with their specific characteristics. 8 pages. American Brake Shoe Co., 530 Fifth Ave., New York 36. N. Y. D

Circle 628 on Page 19

Aluminum-Coated Steel

Manual on Type 2 aluminized (aluminum-coated) steel covers atmospheric corrosion resistance, mechanical properties of the steel base, resistance to fire damage, and heat reflectivity. Typical uses are pictured, and exposure test results are given. 20 pages. Armco Steel Corp., 4157 Curtis St., Middletown, Ohio. G

Circle 629 on Page 19

Thermistor Probe Assemblies

Nine special thermistor probe assemblies are described in Brochure EM-13 and each is identified by its most common application. Probes are used for air, oil, and fuel temperature measurement, surface temperature measurement, and liquid level indication. 4 pages. Fenwal Electronics, Inc., Mellen St., Framingham, Mass. B

Circle 630 on Page 19

Selector Switch Assemblies

Data Sheet 86b on rotary selector switch assemblies describes V3, subminiature, and sealed subminiature switching units. Assemblies are offered with 1 to 8 switching units and from 2 to 8 detent positions. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 631 on Page 19

Glass-Ceramics

Progress report No. 2 deals with Pyroceram Code 9606 and Code 9608 glass-ceramics which can be formed by conventional high speed glass-forming methods. Code 9606 produces a hard, abra-

WHAT'S YOUR WOOD PROBLEM?

Gamble research helps improve CONVEYORS!

THE PROBLEM. Conveyor deflector bars have to be tough enough to withstand the repeated impact of conveyed objects. If they're not, the bars break in the middle or split horizontally. In either case, the result is production equipment downtime as well as maintenance expense.

THE RESULT of Gamble testing and development: a laminated hickory deflector bar that is actually thinner than the old solid-wood "problem" bars. Lamination assures *more uniform* strength (little chance of weakest parts of individual pieces lining up). Hickory assures *greater* and *more consistent* strength. New thinness assures *greater resiliency.* They all add up to longer conveyor life . . . less time spent in downtime for repairs. Perhaps Gamble could help with *your* wood problem.

Send for FREE booklet Illustrating GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Avenue, Louisville 9, Ky.

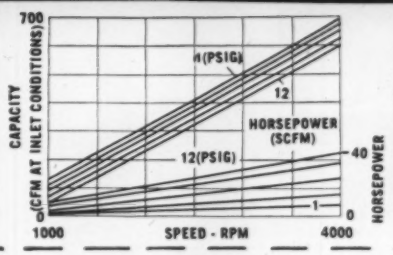
GAMBLE BROTHERS
Incorporated
Louisville 9, Kentucky
If the problem involves WOOD —GAMBLE can help!

Circle 489 on Page 19

Significant Advantages... Every Way You Compare Them!

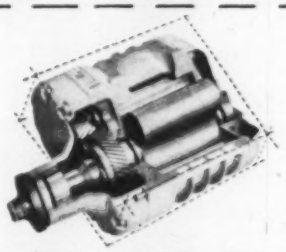
MIEHLE-DEXTER 3-LOBE ROTARY POSITIVE BLOWERS OFFER WIDER PRESSURE AND SPEED RANGE, LESS CUBE, LIGHTER WEIGHT

Pressure Range From 1 to 12 psig; Speed Range From 1000 to 4000 rpm



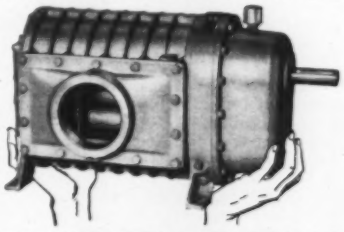
M-D Blowers operate at wider pressure and speed ranges than other rotary positive blowers. The capacity of a typical M-D Blower (Model 4012 with a 4" rotor 12" long) at various pressures and speeds is shown at the left. The capacities of eleven other production models range from 50 to 4000 cfm.

Smallest Cube Dimension of All Rotary Positive Blowers



Less space is required for M-D Blowers than any other rotary positive blower because of the exclusive 3-lobe rotor design. This means M-D Blowers can be integrated into existing systems without requiring major space reallocations. The space-saving advantage of M-D Blowers for original installations is obvious.

Lightest Weight With Aluminum Rotors and Housing



M-D Blowers weigh considerably less because of aluminum rotors and housings, standard for most models. This construction not only simplifies installation but provides greater structural strength. The 3-lobe rotor design provides the capacity you require in smaller space with lighter weight.

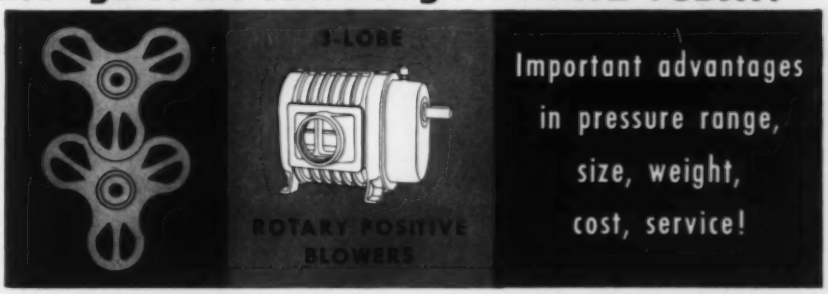
Exclusive Formica Wear Strips On Rotors; Rubber Grid On End Plate

Exclusive formica wear strips on each rotor lobe reduce clearance between rotor lobes and housing to practically zero.

The patented synthetic rubber grid, vulcanized to the metal end plate by a special process, eliminates metal-to-metal contact between the rotor and the end plate — assures longer rotor life and efficient operation.

➔ *The performance figures are convincing . . . WRITE TODAY!*

miehle dexter



MIEHLE-DEXTER DIVISION, RACINE, WIS. • TELEPHONE MELROSE 4-5521 • Another Product of MIEHLE-GOSS-DEXTER, Incorporated

THESE SIGNIFICANT ADVANCES — *STRETCH DESIGN DOLLARS, IMPROVE PRODUCT PERFORMANCE*

Added to Whitney's complete line of precision steel chain drives are new practical approaches to cost reductions and better drive performance.

First, there's Whitney's new *fatigue resistant* Processed Roller Chain—that's establishing service records for durability everywhere. This design advance offsets operational stresses in the chain—solves problems of heavy shock loads and severest operating conditions.

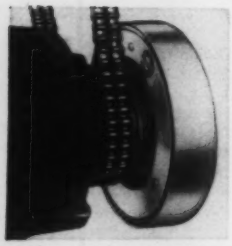
Then there's Whitney's Self-Lubricating Roller Chain—with sintered steel bushings that "oil from the inside"—are pre-lubricated for life. Ideal for installations where conventional chain lubrication may not be practical or desirable. Outlasts conventional chain as much as 5 to 1 in severe operating environments.

And if space limitations or weight are serious factors in power transmission, the new, *compact* Whitney High Capacity Roller Chain may be an effective solution.

Complete details on these design advances will be gladly supplied you.

Factory trained field engineers are available for practical recommendations on all of your chain and sprocket design problems.

Whitney Chain distributors and factory warehouses provide fast off-the-shelf service on a complete line of ASA roller chains, conveyor chains and stock sprockets.



Heard About Whitney-Tormag Magnetic Drives?
For complete motor overload protection, cushioned starts and high efficiency, ask about our new permanent magnet, self-contained power transfer unit. Available in 1 and 2 H.P. units as stock items, additional sizes up to 15 H.P. will follow.
Write for literature.

Whitney
CHAIN COMPANY
302 HAMILTON ST., HARTFORD 2, CONN.

ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVE

sion-resistant end product, whereas Code 9608, with high mechanical strength, is suited for variety of consumer and industrial uses. 8 pages. Corning Glass Works, Corning, N. Y. F

Circle 632 on Page 19

Precision Stamped Gears

Typical examples of precision stamped gears are illustrated along with their major applications, size limits, materials, and finishes in manual. Gear-design suggestions, gear procurement, and basic dimensional data are featured. 20 pages. Illinois Tool Works, Fastex Div., 195 Algonquin Rd., Des Plaines, Ill. J

Circle 633 on Page 19

Delay Lines

The magnetostriction principle and its application to a wide choice of delay lines is covered in loose-leaf Deltime manual. This collection of technical bulletins is kept up-to-date in a plastic binder. Lab-bench, portable, and built-in equipment are covered. Deltime, Inc., 608 Fayette Ave., Mamaroneck, N. Y. D

Circle 634 on Page 19

Gas Regulators

Complete specifications and ordering information for 47 Oxweld gas regulators available for use with all industrial gases are given in Catalog Section 2. Included is a new line of CO_2 regulators and regulator manifolds for late model premix beverage machines. 20 pages. Linde Co., 30 42nd St., New York 17, N. Y. C

Circle 635 on Page 19

Cushioned Air Cylinders

Improved 150-psi air cylinders with adjustable cushions at both ends are subject of descriptive Bulletin 258. Bore sizes 1½ to 6 in. with strokes up to 24 in. are stocked. Specifications and prices are given. 8 pages. Sheffer Corp., 326 W. Wyoming Ave., Cincinnati 15, Ohio. G

Circle 636 on Page 19

Programmable Power Packs

A continuously variable source of super-regulated direct-current, Regatron programmable power packs are described in Bulletin 765. Any voltage value, starting at zero, can be obtained through these power packs. Data on several models are given. 8 pages. Electronic Measurements Co., Eatontown, N. J. E

Circle 637 on Page 19

Hydraulic Line Tubing

Outlining the advantages of electric resistance welded hydraulic line tubing, brochure tells how tubing can be uniformly bent, flared, and assembled. List of specifications and table or recommended working pressures and size ranges are highlights. 10 pages. Republic Steel Corp., Steel & Tubes Div., 224 E. 131st St., Cleveland 8, Ohio. F

Circle 638 on Page 19

AC Voltage Regulator

Technical Data Sheet 281 points up flexibility of operation, regulation accuracy,

Hot Extruded, Cold Drawn Steel Shape

"CUTS COST OF CONTROL PART 50%"

... reports Goss Company

A saving of 50% was accomplished by using a 70-inch long hot extruded, cold drawn shape in this ink control part for a printing press. The section is made of AISI 1018 steel, stress-relieved and cut to length, ready for installation after drilling. The Goss Company formerly machined this part from hot rolled flats in nine operations.

By following hot extrusion with cold drawing, Jones & Laughlin economically produces steel sections of complicated design with extremely close tolerances. Mechanical properties are uniform throughout the bar.

These unique sections can save you time and money by reducing machining operations. Scrap losses are small. Quantities are flexible and the range of sections that can be produced is almost unlimited.

Let us show you how you can directly benefit from this cost cutting process. Call your J&L district office or write direct to Jones & Laughlin Steel Corporation, 3 Gateway Center, Pittsburgh 30, Penna.

J&L STEEL

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

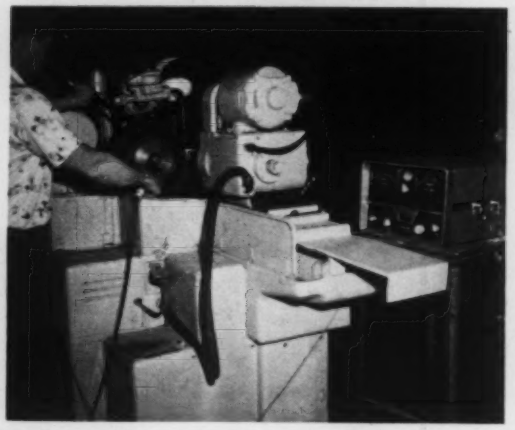
Circle 492 on Page 19

New **IRD** *system*
makes troubleshooting easy,
cuts machinery maintenance costs

Bearing failure, fatigue, chatter, vibration, wear, noise eliminated with new multi-purpose IRD system, like this . . .

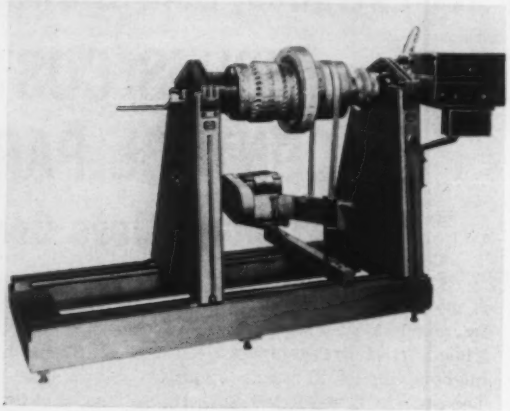
TROUBLESHOOTING
The portable Model 600 Vibration Analyzer pinpoints the parts causing machinery malfunction without costly dismantling, prescribes correction — reducing costly downtime.

IN-PLACE BALANCING
When the trouble is caused by imbalance, the Model 600 is used to dynamically balance rotating components at operating speed, in their own bearings, anywhere in your plant.



Avoid costly duplication of equipment by using the portable, multi-purpose Model 600 as the electronic brain of the IRD Dynamic Balancing Machines.

DYNAMIC BALANCING
IRD Models 101, 102, 103 dynamically balance motors, spindles, turbines, blowers and other rotating components simply, accurately and quickly.



Eliminate costly trial-and-error troubleshooting methods . . . make corrections accurately and quickly, balance components in place or separately. All these important functions are yours at a fraction of the cost of conventional, single-purpose balancing machines. Have an IRD man give you an in-your-plant demonstration, on your machinery.

IRD *systems*
INTERNATIONAL RESEARCH & DEVELOPMENT CORP.
6152 Huntley Rd., Worthington, Ohio
See us in Sweets' 1958 PE and MT files

clean wave form, rapid starting, and other features of Model APR1010 ac voltage regulator. Operation of unit is covered. 2 pages. Sorensen & Co., Richards Avenue, South Norwalk, Conn. B

Circle 639 on Page 19

Malleable Iron

Company facilities for producing tough, ductile malleable iron castings are reviewed briefly in folder. Castings ranging from a few ounces up to 150 lb can be produced. 4 pages. Peoria Malleable Castings Co., Peoria, Ill. I

Circle 640 on Page 19

Copying Equipment

Descriptive Brochure X-255 and Operating Manual X-261 cover Model 1218 copying equipment which allows copying of engineering drawings or accumulative accounting sheets up to 24 x 36 in. onto 12 x 18-in. XeroX plate for transfer to offset paper master. 4 and 8 pages. Haloid Co., Haloid Street, Rochester 3, N. Y. F

Circle 641 on Page 19

High Temperature Fasteners

Tm 9 tension and shear bolts have high static tensile and fatigue strengths at temperatures up to 900° F. They are applicable to jet engine and airframe hot spot uses. Report covers tensile, fatigue, and stress-rupture data. 4 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 642 on Page 19

Pumps

Rotary, hydraulic, and special pumps, as well as hydraulic motors and control valves, are subject of illustrated bulletin. Such design data as service, features, operation, performance, mountings, seals, and available models are tabulated for each unit. 8 pages. Tuthill Pump Co., 939 E. 95th St., Chicago 19, Ill. J

Circle 643 on Page 19

Custom Rubber Parts

Economy in the design and purchase of rubber parts is subject of data chart. It enables designers to specify custom molded products as well as cut parts of natural, neoprene, nitrile, GR-S, Thiokol, and butyl rubber. 1 page. Williams-Bowman Rubber Co., 1951 S. 54th St., Cicero 50, Ill. I

Circle 644 on Page 19

Hydraulic Control Valve

Various configurations of hydraulic directional control valves are described in detail in series of five catalog file sheets No. 1552A40 to 44. Dimensional drawings, performance data, and specifications are given. 2 pages each. Parker-Hannifin Corp., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 645 on Page 19

Stainless Pipe Fittings

Uses and advantages of Quikupl stainless steel fittings for pipe applications are related in Catalog 50.0. Elbows, tees, couplings, reducers, and adapters for 1 to 4-in. OD tube and IPS sizes are

Circle 493 on Page 19

STAR-KIMBLE *reports to industry*

One of a series of advertisements describing unusual electro-mechanical problems solved by S-K engineering and equipment. You may have a similar problem—or a completely different one. In either case, bring it to Star-Kimble.

DISASSEMBLED AND AIRBORNE IN 1 HOUR -- that was a basic design requirement for brakemotors powering portable aircraft hoists. Other essentials included extremely light weight, very high power output per unit of volume and very low level of radio interference. S-K custom engineered the design for a manufacturer of special Air Force equipment and has built many units. Power supply for the brakemotors is 28 volts d-c; hoist must be capable of lifting a load of 10,000 pounds; provision is made in the S-K design for regulating the speed of the hoist when load is being lowered.

PURE SINE WAVES FROM 2 to 2000 CPS are needed in the power supply of a massive vibration exciter with continuous rated force output of 12,500 pounds and capable of attaining accelerations up to 10 g with loads of 975 pounds. Precision measurements are based on sinusoidal table motion. Heart of the machine is the S-K rotary power unit comprising: 75 hp 60 cycle motor; 460 v. d-c generator; 230 v. field exciter; 460 v. variable speed d-c motor; and two pure sine wave alternators, one covering the range from 2-500 cps, the other 500-2000. No capacitors are needed for power factor correction over entire range.

IN AND OUT OF COLD STORAGE go the lift trucks that shuttle back and forth in refrigerated warehouses, passing from temperatures of -38° to normal ambients. Starting with its standard design for electric truck motors, S-K developed a special varnish treatment for the Class B insulation to enable it to withstand the severe moisture condensation encountered. This varnish treatment is used on both drive and pump motors, which have been in daily service for periods as long as five years under severe loading conditions; motors have required little or no maintenance.

Circle 494 on Page 19

STAR-KIMBLE INDUSTRIAL MOTOR DIVISION
SAFETY INDUSTRIES, INC.
P. O. BOX 904 NEW HAVEN, CONN.

MOTORS • GENERATORS • DISK BRAKES • SPECIAL ROTATING AND CONTROL PACKAGES

Norgren AUTOMATIC-DRAIN Air Line Filters

Now—30 Models to Choose From
Transparent and metal bowls—
¼", ⅜", ½", ¾", 1".

Better Protection for your Air Equipment

- **Removal of corrosive Liquids is Highly Efficient** Efficiency has been increased—even at air flows up to 143% higher than most filters available today.
- **Damaging Solids Are Removed**—Choice of interchangeable 74, 64 or 25 micron filter elements.
- **Wide Operating Pressure Range**—Top efficiency at as low as 5 psi. As high as 250 psi for metal bowl type.
- **Wide Operating Temperature Range**—Metal bowl models extend temperature range to 200° F.
- **Will Withstand Rough Usage**—Metal bowl models are ideal for applications likely to get rough usage.
- **Eliminates Cost of Manual Draining**—Collected liquid is drained automatically as long as pressure is on the system.

For complete information, call your nearby Norgren Representative listed in your telephone directory—or WRITE FACTORY FOR NEW No. 900 CATALOG

C. A. NORGREN CO.

If it's Norgren . . . It's Dependable.

3442 SOUTH ELATI STREET ENGLEWOOD, COLORADO

available in stainless steel alloys 304 and 316. Resistances of materials to more than 303 chemicals are tabulated. 8 pages. Vanton Pump & Equipment Corp., 201 Sweetland Ave., Hillside, N. J. D

Circle 646 on Page 19

Self-Locking Setscrews

File folder type "Setko Selector Chart" aids in selecting the correct self-locking setscrew for any given purpose. Chart indicates various combinations of metals, locking actions, drives, points, and sizes available from stock or made to order. Over 1000 combinations are listed. Set Screw & Mfg. Co., Bartlett, Ill. I

Circle 647 on Page 19

Steel Tubing Data

"Weight Tables for Round Steel Tubing" is title of reference manual on this material. Decimal equivalents are given for fractional parts of a foot. 16 pages. Revere Copper & Brass Inc., Box 111, Rome, N. Y. C

Circle 648 on Page 19

Latch Relays

Details of a new line of mechanically-held latched-in relays for electrical control purposes are described in Bulletin 7305-PML. Nine standard models for space-saving panel mounting and with from 2 to 10 poles are covered. 4 pages. Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio. F

Circle 649 on Page 19

Gears

Spur, helical, bevel, miter, internal, worm, segment, lead, and feed gears; worms; sprockets; ratchets; splined shafts; racks; speed reducers; and special transmissions are among the standard and special products that can be provided by this company. Details are given in Circular C-104. 4 pages. Adams Co., Dubuque, Iowa. I

Circle 650 on Page 19

Electric Motors

Single phase and polyphase direct current motors in ½ to 30-hp ratings are briefly described in Bulletin SDA-155. Design features, ratings, and frame sizes are listed. 8 pages. Peerless Electric Co., 1401 W. Market St., Warren, Ohio. G

Circle 651 on Page 19

Special Steels

Complete specifications and design information are presented on stainless steel, electrical materials, Carmet carbides, and tool steels in Bulletin AC4-656. All data are conveniently tabulated for reference purposes. 16 pages. Allegheny Ludlum Steel Corp., H. W. Oliver Bldg., Pittsburgh 22, Pa. F

Circle 652 on Page 19

Fluid Controls

Small valves for use in instrumentation, design, chemical processing, nucleonics, and general industries are shown and specifications are given in Catalog MV-957. Types covered include miniature

Circle 495 on Page 19

Circle 496 on Page 19→

so quiet...

Just one of the reasons these electric motor manufacturers use Hoover Quality Ball Bearings

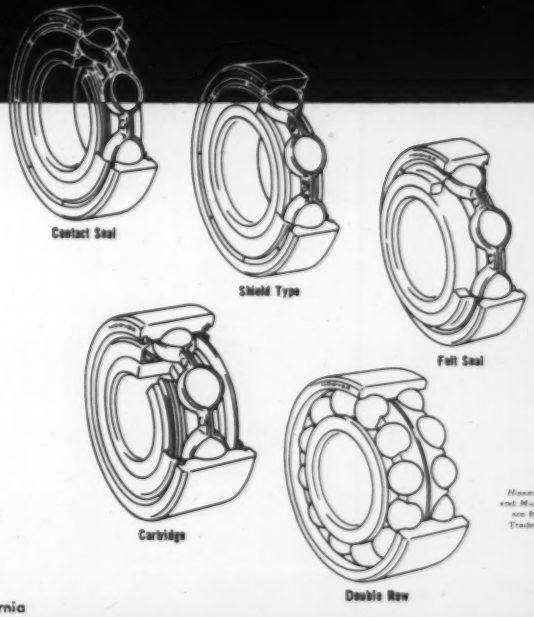
Allis Chalmers Manufacturing Company
The Louis Allis Co.
Baldor Electric Company
The Brown Brockmeyer Company
Century Electric Company
Cleveland Electric Motor Company
Continental Electric Co., Inc.
Diehl Manufacturing Co.
Doerr Electric Corporation
Electro Dynamic
Electric Machinery Mfg. Co.
Elliott Company
Emerald Motor & Mfg. Co.
Emerson Electric Mfg. Co.
Fairbanks, Morse & Co.
General Electric Company
Howell Electric Motors Company
The Ideal Electric and Manufacturing Company
The Imperial Electric Company
Iron Fireman Manufacturing Co.
Jack & Heintz, Inc.
Kingston Conley Incorporated
The Leland Electric Co.

The Luma Electric Motor Co., Inc.
The Lincoln Electric Company
Marathon Electric Manufacturing Corporation
Marble Card Electric Corporation
The Master Electric Company
Oak Electric Motors, Inc.
Packard Electric Division
The Peerless Electric Company
The Piqua Machine & Manufacturing Co.
The Reliance Electric & Engineering Company
Robbins & Myers, Inc.
Reuland Electric Company
The Springfield Electric Motor Co.
Star Kimble
Sterling Electric Motors, Inc.
Valley Electric Corporation
Wagner Electric Corporation
The B. A. Wesche Electric Company
Bogue Electric of Canada, Ltd.
American Electric Motors
A. O. Smith Corporation
Oster Manufacturing Company
Dayton Electric Service Co.

Constantly sought by manufacturers and users is velvet smooth operation of electric motors that whispers "*superb quality.*"

In many leading makes of motors, as well as other products, hushed quietness is assured through the use of Hoover Quality Ball Bearings. Precision made with super smooth *Hoover Honed* Raceways and perfectly matched *Micro-Velvet* Balls, Hoover Ball Bearings are exceptionally quiet, exceptionally dependable, exceptionally long lived.

You, too, can put these Hoover advantages to work . . . in the products you build, in the equipment you operate.



hoover

BALL AND BEARING COMPANY
ANN ARBOR, MICHIGAN
Los Angeles Sales Office and Warehouse: 2020 South Figueroa, Los Angeles 7, California

Hoover Honed and *Micro-Velvet* are Hoover Trademarks.

Please send the literature checked:
Bulletin 100—Lubricated-for-life ball bearings with seals of TEFLON*.
Hoover Handi-Book of Anti-Friction Bearings which outlines bearing types, problems, applications.
Bulletin 101—Hoover *Micro-Velvet* Balls of chrome steel, stainless steel, brass, bronze, monel.

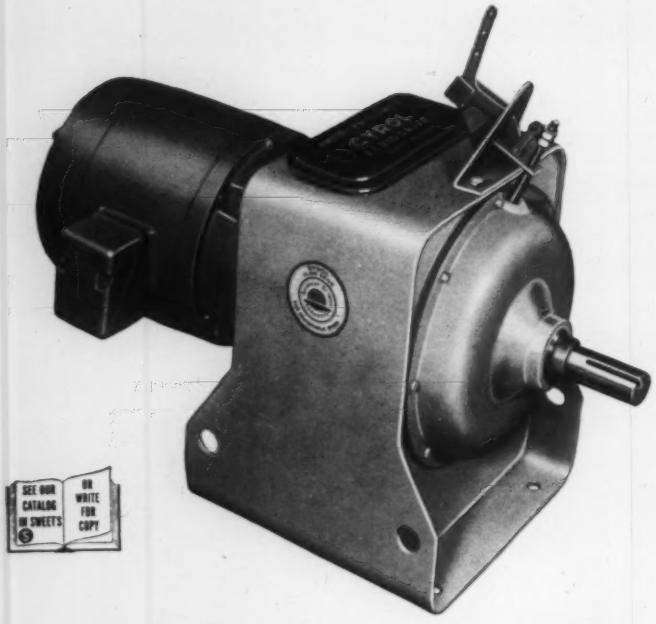
*TEFLON is a Du Pont Trademark.

Hoover Ball and Bearing Company
Ann Arbor, Michigan

Name_____
Title_____
Company_____
Address_____
City_____ State_____

Get full value from adjustable-speed drive:

American Blower *Gýrol*® Fluid Drive varies speed steplessly without costly maintenance

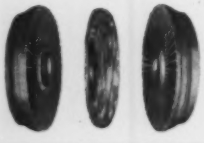


Feature for feature, American Blower Gýrol Fluid Drive is your most economical solution to many industrial-drive problems. Here's why:

- **Stepless speed control**—simple, wear-free speed controller; manual or automatic operation.
- **Shock protection**—vortex of oil isolates shock; protects costly machines.
- **Controlled acceleration**—permits no-load starting—gradual application of power to accelerate the load.
- **Full reversibility**—fast, easy; just change motor rotation even when running; provides dynamic braking.

Compact and self-contained, Type VS, Class 2 Gýrol Fluid Drives come in a complete range of sizes from 1 to 800 hp. Other designs handle up to 12,000 hp. Get full information today from one of our 73 branch offices! Or write: American-Standard*, American Blower Division, Detroit 32, Mich. In Canada: Canadian Sirocco products, Windsor, Ont.

COMPARE . . . THEN SPECIFY GÝROL® FLUID DRIVE!

Feature	Shock Protection	Maintenance Record	Accuracy	Service Limit	Horsepower Rating
GÝROL FLUID DRIVE Type VS, Class 2 	Vortex of oil isolates shock.	Good—few wearing parts; extra-long service life.	Simple, wear-free speed control.	Unlimited—all Gýrol Fluid Drive ratings are for continuous service.	Units available up to 800 hp.
FRICTION-TYPE DRIVE	Mechanical connection transmits shock.	Poor—multiple wearing parts; power transmitted by friction.	Wear and tension affect control.	Limited—service factors influence selections.	Units available up to 100 hp.

* American-Standard and Standard ⊕ are trademarks of American Radiator & Standard Sanitary Corporation.

AMERICAN-Standard
AMERICAN BLOWER DIVISION

forged needle, panel mounting, bar stock needle, corrosive service, union bonnet globe, spring-closing and cam-closing toggle, metering, and check valve. 12 pages. Hoke, Inc., 136 S. Dean St., Englewood, N. J. D

Circle 653 on Page 19

Steel Castings

How steel castings are produced is shown pictorially in bulletin entitled "Tomorrow's Steel Castings Today." Booklet takes reader on a trip through the plant and points out the innovations that have been devised to produce modern quality castings of stainless, alloy, and carbon steel for use in various industries. 18 pages. Empire Steel Castings, Inc., Reading, Pa. E

Circle 654 on Page 19

Hydraulic Flow Control

The new Flo-Set 1000 speed control valve, for hydraulic service to 1000 psi, is designed to control piston speeds of hydraulic cylinders and other hydraulically powered devices. Full information is given in Bulletin 275 on ¼, ⅜, ½, and ¾-in. sizes. Units are adjustable and calibrated for speed control. 2 pages. Hanna Engineering Works, 1765 Elston Ave., Chicago 22, Ill. I

Circle 655 on Page 19

Coatings for Aluminum

A complete line of protective and prepaint coating chemicals for aluminum is discussed in Bulletin 1424A. Such subjects as advantages of coating, methods of application, and equipment used are covered. Typical metal products treated are included in a selection chart. 4 pages. American Chemical Paint Co., Ambler 1, Pa. E

Circle 656 on Page 19

Rivets & Fasteners

Commercial Huckbolt fasteners, blind rivets, and driving tools are detailed in Form No. 8-416. Available in a wide range of sizes and materials, fasteners are suited for metal fabrication. 12 pages. Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich. H

Circle 657 on Page 19

Industrial Closures

Metal and plastic closures for sealing and protecting internal and external threads on tubing, fittings, and parts are described in Form 3501. Types and sizes are offered for AN and SAE threads and fittings. Prices are given. 24 pages. Clover Industries, Inc., 578-588 Young St., Tonawanda, N. Y. F

Circle 658 on Page 19

Chemical Pumps

Sigmamotor pumps force liquids, solutions, or gases through tubing. Details of these progressive tube-squeezing type pumps are given in illustrated bulletin. Capacities range to 275 gph at 600 rpm. 12 pages. Sigmamotor, Inc., 3 N. Main St., Middleport, N. Y. F

Circle 659 on Page 19

PLUS
protection
against
overload

Maxitorq

overload release clutches

Designers and builders have found MAXITORQ Overload Release Clutches the ideal way to provide dependable protection against overload conditions.

Unlike such devices as shear pins, the MAXITORQ Overload Release Clutch requires no dis-assembly or replacement after functioning. Once the cause of overload is removed or corrected, the machine may be re-started at once. Furthermore, MAXITORQ Overload Release Clutches may be adjusted for pre-determined overload protection.

In addition, users enjoy the proved advantages of the MAXITORQ Floating Disc Clutch . . . smooth, positive engagement and release . . . "floating" neutral with no drag or heating . . . easy manual adjustment.

We will be glad to give you the benefit of our long and successful experience in clutch and brake design; the overload release clutches are only one of many advanced MAXITORQ developments in both manual and electrically operated applications. Ask for literature, or outline your problem . . . write Dept. MD-4.

THE CARLYLE JOHNSON MACHINE CO.
Manchester, Connecticut

2CJ58

Circle 498 on Page 19

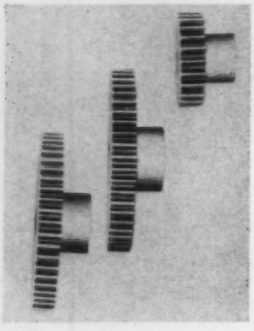
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Gears

in 1/16-in. face widths are available from stock

Cut to Precision Class I and II tolerances, miniature gears are now available in 1/16-in. face widths from stock, with 1/32 and 3/32-in. widths also available. Gears are furnished in aluminum or stainless in 72, 96, and 120-diametrical pitch



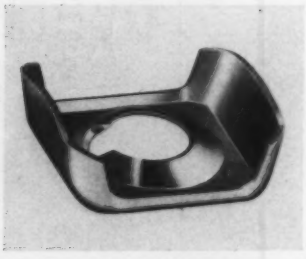
with 20-deg pressure angle. All gears have stainless hubs, and are assembled by staking and pinning. Bore sizes are 0.0937 through 0.1875 in. **Dynamic Gear Co. Inc.**, 20 Merrick Rd., Amityville, N. Y. D

Circle 660 on Page 19

Lock Nut

for No. 8-32 screws in blind applications

Tempered spring-steel self-retaining lock nut is designed to serve as a captive nut for No. 8-32 screws in blind applications. Flared sides push into and retain nut in slot or cavity. Shape is suited to fast, low-cost hopper feeding or automated insertion into cavities. Self-locking thread form exerts spring grip on threads to resist loosening under vibration. Tightening torque of 10 lb-in. assures maximum locking action. Nut measures 0.140 in. high and is assembled in a slot 0.370 ±0.005 in. wide. Stocked in zinc



peen finish, it is also available in cadmium or plain finish. **Palnut Co.**, 61 Glen Rd., Mountainside, N. J. D

Circle 661 on Page 19

Cadmium Strip and Foil

in thicknesses as low as 0.0005 in.

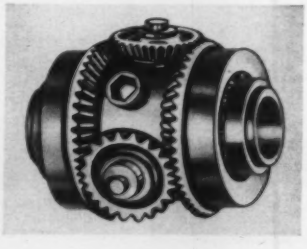
Applications for cadmium strip and foil, rolled to thicknesses as low as 0.0005 in., include neutron shields, tape-type cables used in printed circuitry, batteries, cells, radio sets, electrical contacts, and as a foil wrapping where protection from corrosion is required. Metal is precision rolled to widths from 4 to 6 in., in thicknesses from 0.300 to 0.0005 in., and to tolerances as close as ±0.0001 in. **American Silver Co. Inc.**, 36-07 Prince St., Flushing 54, N. Y. D

Circle 662 on Page 19

Miniature Differential

for ⅛-in. shaft

New differential is designed for miniature servo and computer applications. Weighing only 0.2 oz, it is available for ⅛-in. shaft. Maximum load rating of 5 to 6 oz-in. and 500 rpm maximum operating speed are recommended. **Electronics Div., Waldorf Instrument Co.**, Huntington Station, L. I., N. Y. D

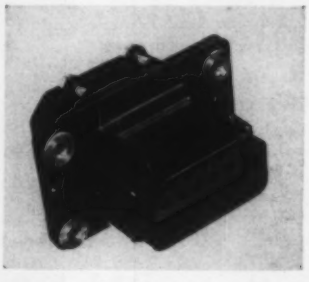


Circle 663 on Page 19

Rack-Panel Connector

is constructed of magnesium

DPSM magnesium rack-panel connector is adaptable to cable-connecting plug or receptacle applications. Use of magnesium for shell of unit affords a 26 per cent reduction in weight over aluminum models and permits continuous operation at temperature range of −65 to 300 F under high vibration. Unit incorporates a sliding seal which permits ⅛-in. axial tolerance while still effecting a seal and maintaining electrical characteristics at high altitudes. **Cannon Electric Co.**, 3208 Humboldt St., Los Angeles 31, Calif. L

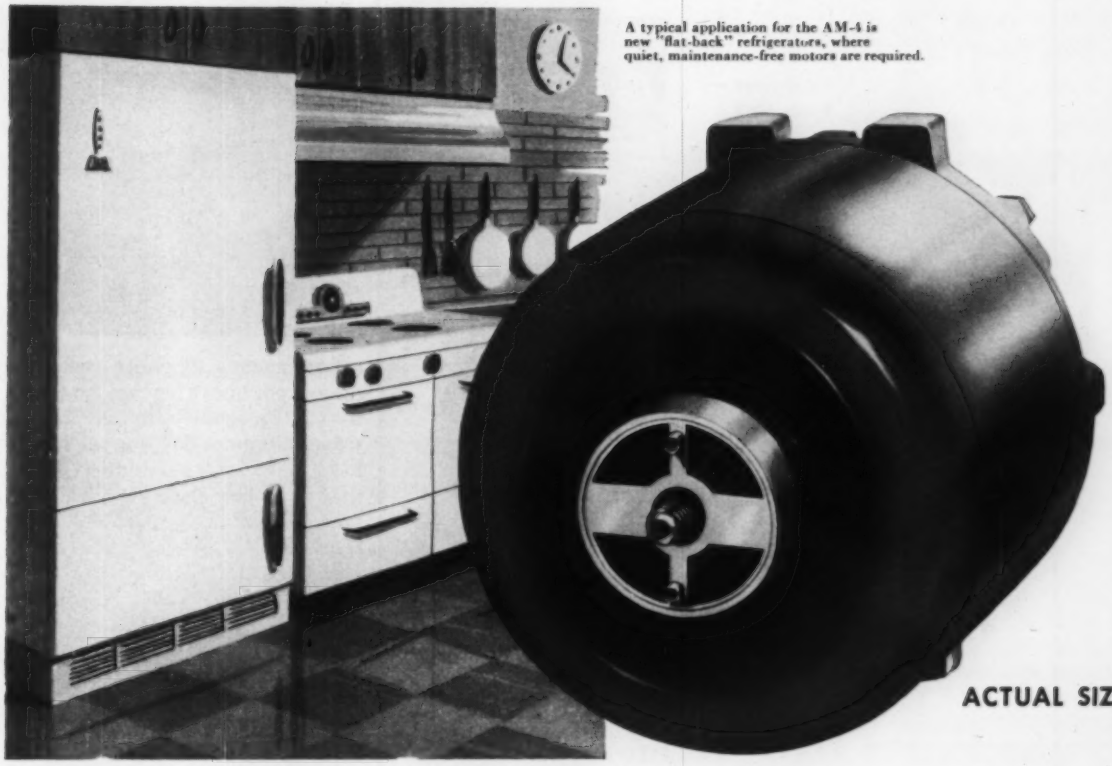


Circle 664 on Page 19

Four-Way Valves

in ¼, ⅜, and ½-in. NPT pipe sizes

New series of 0-250 psi, manual, four-way air and oil valves incorporate Shear-Seal leakproof design, preventing internal and external leakage. Valves are available in standard three-position and spring-



A typical application for the AM-4 is new "flat-back" refrigerators, where quiet, maintenance-free motors are required.

ACTUAL SIZE

Redmond AM-4 Is Designed Specifically for Refrigeration and Air Conditioning Industries

Adaptable Wherever a Long-Life, Permanently Lubricated, All-Angle Motor Is Needed

The AM-4 MicroMotor is designed and constructed to be the finest refrigeration condenser-fan motor available. It is the only motor of this type that is backed with a full two-year warranty. The AM-4 never needs oiling—an extra large quantity of lubricant is completely suspended and uniformly distributed in pure wool and nylon wicks, and permanently sealed to guarantee against oil leakage in use or shipment.

Although designed specifically for the refrigeration and air conditioning industries, the AM-4 single-bearing MicroMotor is ideally suited for other heavy-duty domestic and commercial applications where quality, long life, and permanent lubrication are important.

Write, wire, or telephone either the Redmond office nearest you, or the home office, and our sales engineers will help you adapt the AM-4 to your motor needs.

Your Nearest Redmond Engineering Field Office Has Complete Information for You

Eastern Office
850 Broad Street
Newark 5, New Jersey
Phone: Mitchell 2-3990

Southeast Office
1720 Section Road
Cincinnati 37, Ohio
Phone: Melrose 1-3153

Mid-West Office
Fair Oaks Bldg.
6525 W. North Ave.
Oak Park, Illinois
Phone: Village 8-5721

Southwest Office
210 Suburban Building
5526 Dyer Street, Dallas,
Texas Phone: FOrest 8-4461

Western Office
11526 Burbank Blvd.
No. Hollywood, California

FREE BROCHURE

For the complete story on the AM-4 motor—dimensions, performance, operational data, and suggested applications—write the Redmond Co., Owosso, Michigan for the "AM-4 Bulletin."

MAIN OFFICE
201 Monroe Street
Owosso, Michigan
Phone: Saratoga 5-5151

ADVERTISED IN The Saturday Evening POST

The Standard of Dependability

Redmond COMPANY, INC.
OWOSSO, MICHIGAN

THE BIG NAME IN SMALL MOTORS

Circle 499 on Page 19

Here's the **NEW** variable-speed, explosion-proof Model 16AM

GAST rotary vane AIR MOTOR

Newest and largest Air Motor in the Gast line, this Model 16AM may solve an original equipment (or plant use) problem for you! It's compact — only 14⅜" x 8" x 7⅝" high. It's light in weight — only 65 pounds. It delivers up to 7 h.p. with good torque characteristics.

Listing at $200, it offers unique advantages for driving equipment located near a compressed air source:

1. Speed infinitely variable from 300 to 2,000 r.p.m. with any simple air valve control. Air motors always run cool.
2. Explosion-proof design, safe in explosive atmospheres.
3. Can't burn out from overloads — stalling doesn't harm it.
4. Heavy-duty construction with ball bearings, dual seals.
5. Six vanes in rotor automatically take up their own wear for constant high efficiency and long life.

Designed to operate on air pressures from 30 to 90 p.s.i., Model 16AM is suitable for driving direct, through gear box or pulley. Foot (base) is standard. End plate also has four tapped holes for flange mounting to gear box or other driven unit.

Perhaps you can use air power on a hoist, fan, pump, mixer or other product. Write today for new Bulletin 16AM.

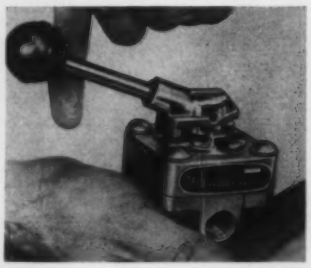
GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"



return models to either center or reverse position. They are furnished in ¼, ⅜, and ½-in. NPT pipe sizes. Minimum flow passage ranges from ⅜ to 9/16 in. in diam. Rated flow at 20 fps ranges from 7 to 15.5 gpm, according to port size. Mechanical parts are stainless steel and aluminum to eliminate corrosion. **Control Valve Div., Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif. L

Circle 665 on Page 19

Flexible Nylon Coupling

handles loads from fractional to 40 hp

New lubrication-free nylon coupling is constructed of nylon segments and stainless-steel pins. It can be disassembled or connected at any link without special tools, and fits standard steel roller-chain sprockets. Coupling handles loads from fractional to 40 hp and speeds from 500 to 5000 rpm. **Morse Chain Co.,** Ithaca, N. Y. D

Circle 666 on Page 19

Speed Reducers

with 1/3 to 5-hp ratings

Four worm-gear speed reducers combine maximum load-carrying capacity with minimum center distances. Units have input ratings of 1/3 to 5 hp. Each of the four types—Type S (worm at bottom), Type T (worm

PRODUCT-DESIGN MEMOS FROM DUREZ

High-impact phenolic | **Automatic molding**
Phenolic for appliances

Flying saucer?

This plastic housing helps airmen find out what's cooking on the roof of the world.

It's part of a radiosonde, a device that has sparked many flying-saucer reports.

Dropped from a high-flying weather reconnaissance plane over an ocean or arctic ice, the radiosonde flips its plastic lid, releasing a parachute.

The ballooning chute yanks an antenna line out of the case. Then, as the device drifts groundward, it broadcasts a code report on air temperature, pressure, and humidity every six seconds.

Picked up by radio men, these signals enable the Air Force to piece together accurate forecasts of flying weather over remote frontiers.

The snap-off housing is molded of *Durez 16771 Natural*, selected for its impact strength and its ability to stand extremes of temperature and humidity.

In sharp contrast to the mass production of phenolic parts, this use of Durez suggests its ability to meet *your* out-of-the-ordinary requirements.

If you'd like technical data on 16771 Natural, check the coupon. For information on other special-purpose phenolics, write us, outlining the problem.

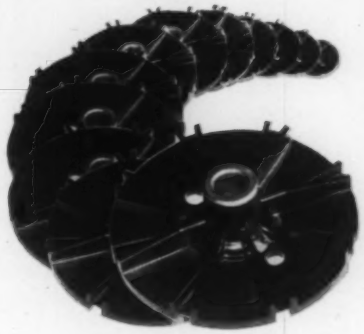
Big job, big saving

What's hot in phenolics? *Automation.*

Automatic molding of a 4¾-inch diameter water-pump impeller for new Ford cars, trucks, and tractors has made possible a switch from cast iron to phenolic —with substantial reductions in weight, production time, and cost.

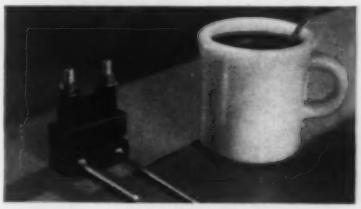
The impellers are molded 12 at a shot on the largest capacity compression molding press ever to operate on fully automatic cycle.

The material selected for the impeller is a Durez phenolic impervious to antifreeze and antirust solutions, combining moisture resistance with dimensional stability in high degree.



Thinking big? You'll find there are many ways in which mass-production molding and Durez phenolics can team up profitably for you. The versatility and exceptional batch-to-batch uniformity of these compounds assure best possible results on highly automated production lines.

Ask your molder or your Durez sales representative to suggest how you can put these advantages to work in your products.



Durez and the coffee-break

Appliance makers can tell you that wherever coffee perks, bubbles, or pours into a cup, there's likely to be a Durez phenolic close by.

Electrical components, handles, knobs —these are just a few essentials of a coffee-break, in which Durez molding compounds play an unassuming part.

A prime requisite for this sort of assignment is the ability of phenolic to resist coffee stains and chemical deterioration. The appliance designer also looks for:

- excellent surface finish
- good dimensional stability
- coolness to the touch
- crack resistance when molded around large inserts

If *you're* looking for properties like these, you can find them all in *Durez 791 Black*. They're exemplified in the component shown here, an electrode assembly for a king-sized coffee maker and dispenser.

For more facts on versatile 791 Black, check the coupon.

For more information on the Durez materials mentioned above, check here:

- ☐ High-impact Durez 16771 Natural—data sheet
- ☐ Phenolic molding compounds—descriptive bulletin
- ☐ General-purpose Durez 791 Black—data sheet

Clip and mail to us with your name, title, company address. *(When requesting samples, please use business letterhead.)*

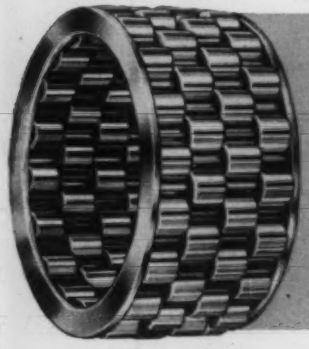
DUREZ HOOKER CHEMICALS PLASTICS

PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
504 Walck Road, North Tonawanda, N. Y.

Circle 501 on Page 19

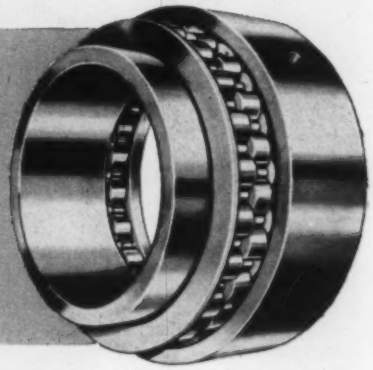
Why ORANGE *STAGGERED* ROLLER BEARINGS

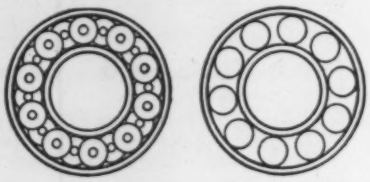
carry heavier loads--run more smoothly--provide longer life



STAGGERED ROLLER DESIGN

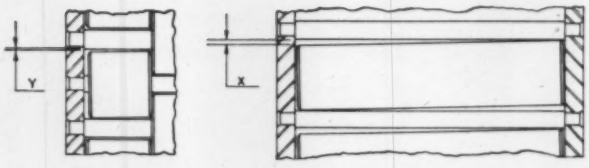
By using many short rollers in staggered arrangement instead of fewer long rollers as in conventional bearings, Orange "Staggered" Roller Bearings provide outstanding advantages for heavy-duty, highly-stressed and precision applications. They do the work of larger straight roller bearings—save space, weight and cost—assure long, trouble-free operation.





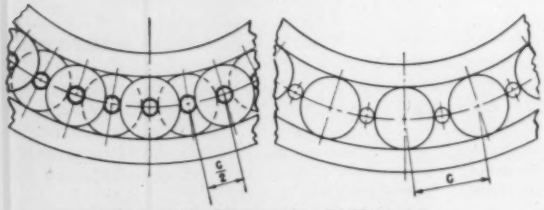
MORE ROLLERS SUPPORT THE LOAD

End views of "Staggered" roller bearing (left) and conventional bearing, show how many short rollers distribute the load over a multiplicity of contact points within the loaded zone.



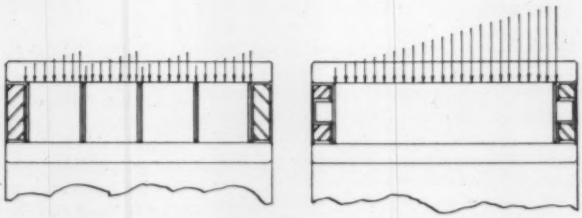
GREATLY REDUCED ROLLER SKEWING

For a given angular misalignment, a short roller tends to skew only a fraction that a long roller will skew. Each row of rollers aligns itself independently, whereas a long roller has the tendency to skew along its full length.



HALF THE CHORDAL DISTANCE

Staggered rollers, with closer centers, provide a much smoother running bearing. This is especially beneficial when rolling sheet or foil, and provides better tone in rotogravure printing applications. More pins add greater rigidity to the cage.



REDUCED EDGE LOADING—BETTER FATIGUE LIFE

Dimensional deviations of component parts or uneven loading cause edge loading of rollers. Illustration shows greatly reduced effect on short staggered rollers compared with long straight rollers.

Available in a complete range of sizes interchangeable with other bearings in the 200 and 300 series.

WRITE for 40-page Engineering Reference Manual giving full specifications of "Staggered" Roller Bearings and other Orange Roller Bearings.

ORANGE
ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

at top), Type L (low base vertical output shaft up), and Type H (high base vertical output shaft down)—is available in four sizes from 2 to 3⅜ in. center distances. Each

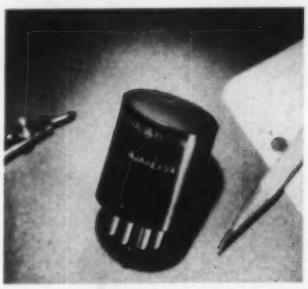
size is available in six ratios from 10 1/3:1 to 60:1, providing a wide range of output speeds and power. **Foote Bros. Gear & Machine Corp.**, 4545 S. Western Blvd., Chicago 9, Ill. I

Circle 667 on Page 19

Rectifier Circuits

are potted in epoxy resin

Complete germanium or silicon rectifier circuits are potted in epoxy resin in octal-socket tube bases. Any standard or special rectifier circuit requiring from one to six low-current germanium or silicon rectifier cells can be supplied. Seven 150-C silicon-rectifier-cell units are rated from 50 to 600 v piv. Six 125-C silicon-cell units are rated from 100 to 600 v piv. Potted rectifier circuits, containing three germanium recti-



fier cells rated at 100, 200, or 300 v piv, are also available. Standard circuits available are single phase half wave, single phase center tap, doubler, single-phase bridge, single-phase open bridge, three-phase half-wave bridge, three-phase bridge, and six-phase star. Individual rectifier cells can be used at full free-air

(*Please turn to Page* 182)

New HIGH POWER 60 AND 400 CPS TRANSI-MAGS®

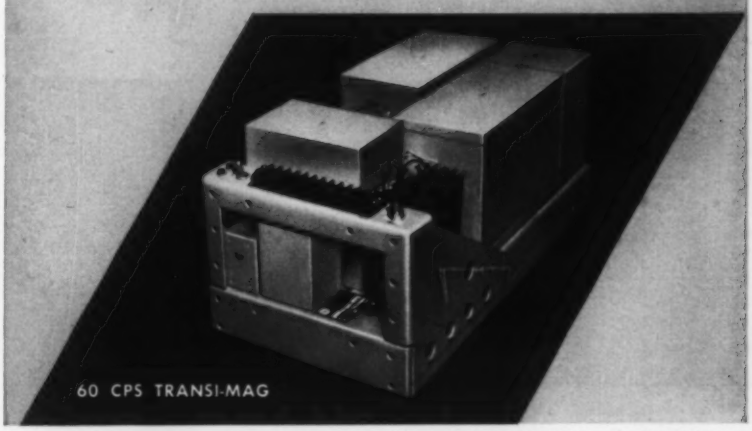
STANDARD LINE OF FAST RESPONSE

TRANSISTOR MAGNETIC AMPLIFIER

FOR SERVO MOTOR CONTROL

For driving AC servo motors in industrial and military servo systems which require hi-power, fast response and (static) high reliability.

A COMPLETE SERVO AMPLIFIER DRIVE SYSTEM IN A SINGLE PACKAGE
TEMPERATURE STABILIZED
FAST RESPONSE
HIGH GAIN
INSTANTANEOUS START
SMALL STANDBY POWER
RUGGED
HIGH RELIABILITY
QUADRATURE REJECTION
SERVO MOTOR COMPATIBILITY



60 CPS PERFORMANCE SPECIFICATIONS

For complete 60 CPS and 400 CPS Transi-mag specs Write For Bulletin S-890.

MODEL A.C. INPUT D.C. INPUT	TMA-1501 TMA-1511	TMA-1551 TMA-1561	TMA-1571 TMA-1581	TMA-1601 TMA-1611	TMA-1701 TMA-1711	TMA-1801 TMA-1811	TMA-1901 TMA-1911
MAX. POWER OUTPUT WATTS	50	100	120	175	650	1900	2800
TYPICAL SERVO MOTOR LOAD	Diehl FPF49-9	Diehl FPF49-12-1	Diehl FPF66-11-1	Diehl FPF85-18-1	Diehl ZP105-2212-1	Diehl ZP143-2247-1	Diehl ZP162-2207-1
SENSITIVITY	A.C. Input — 0.3 volts A.C. for full power output D.C. Input — 0.15 volts D.C. for full power output						
RESPONSE	.05 seconds						
AMBIENT TEMPERATURE	− 55°C. to + 71°C						

MAGNETIC AMPLIFIERS INC.

632 TINTON AVENUE • NEW YORK 55, N. Y. • CYPRESS 2-6610

West Coast Division

136 WASHINGTON ST. • EL SEGUNDO, CAL. • OREGON 8-2665

Circle 503 on Page 19

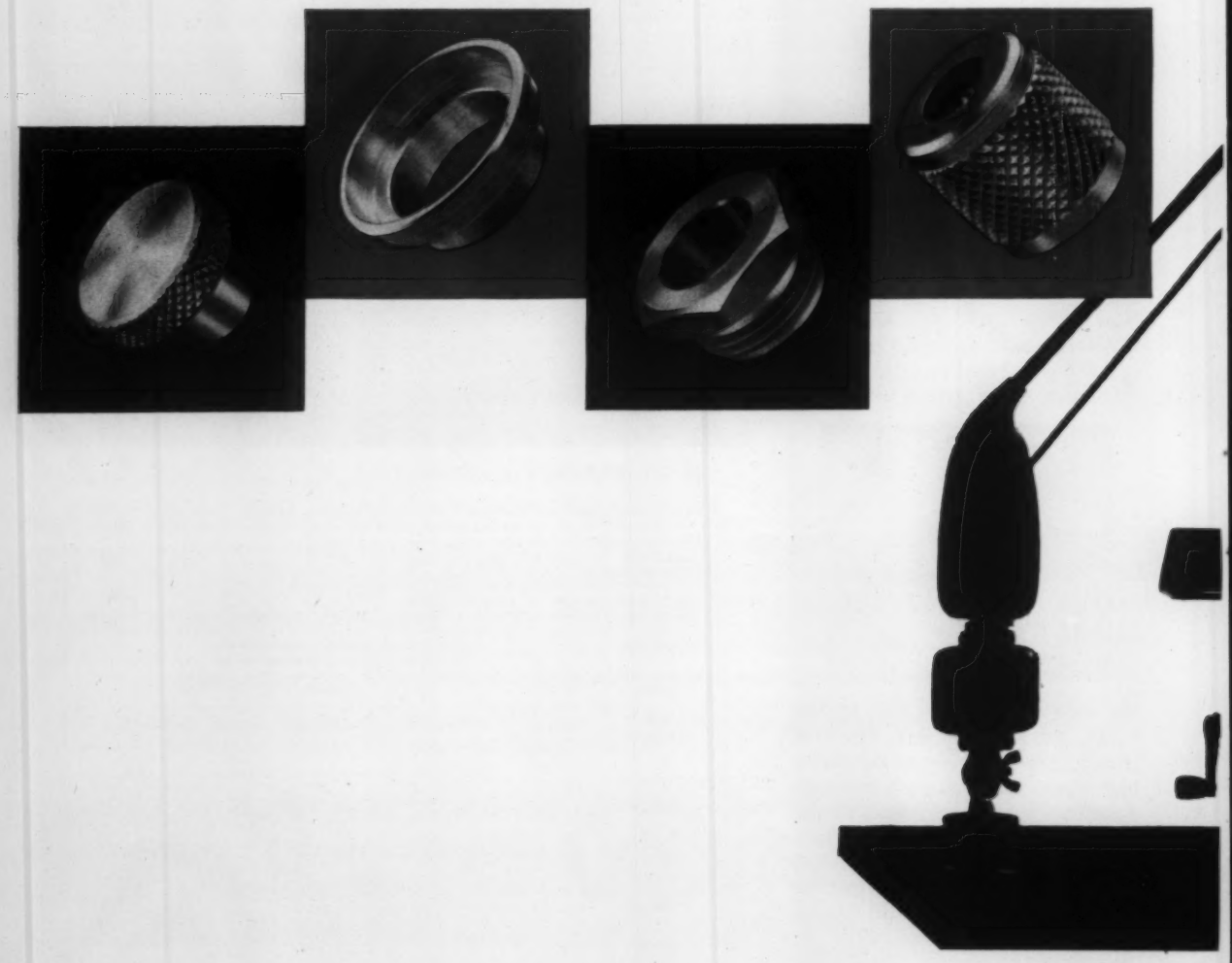
WHAT THE DESIGNER CONCEIVES . . . ALUMINUM ACHIEVES

ALUMINUM'S PRESENT WIDE USE and its increasing importance in all types of fabricating are helping create advanced concepts throughout the fields of metalworking and design.

For screw machine production in particular, aluminum machining has pointed the way to new, better and faster methods of parts production for all ferrous and non-ferrous metals. For example—thanks to aluminum—speeds of equipment are common today which a few years ago would have appeared almost unbelievable.

What are the advantages of screw machine production? To help designers make full use of up-to-date developments, the following checklist presents 12 advantages of modern screw machine production:

1. Starting material is a wrought product which gives high properties in the finished part.
2. Very fine threads possible—as well as accurate threading.
3. Excellent finishing possibilities—anodizing, etching, buffing, etc. As-machined finish gives very fine surface.
4. Closer tolerances and more intricate parts possible than with other methods. Mating parts match better.
5. Excellent concentricity is guaranteed.
6. Fewer rejects for porosity when compared to a cast part.
7. Lower costs for production tooling, dies, set-up; faster delivery of finished parts possible due to fast availability of tooling, speed of set-up.
8. Modification of parts in production easier and less costly.
9. Wide range of equipment and facilities available throughout the country.
10. Fewer secondary operations necessary; possible to avoid secondary finishing by using the as-machined surface.



11. Lower costs for actual production due to high rates of production with available new equipment.

12. Lower costs for finished parts due to competitive pricing among large number of suppliers.

ALUMINUM IN SCREW MACHINE PRODUCTION offers designers more useful properties than any other metal. Check this list of 12 aluminum advantages:

1. Light weight—moving parts present less resistance to applied force, wear less; chips float out of recesses better for cleaning finished parts. Easier handling of raw material in plant, lower freight costs on finished parts.
2. Non-magnetic.
3. Corrosion resistant—can often eliminate finishing.
4. Non-sparking.
5. Lower raw material cost per part.
6. Greater conductivity—helps dissipate machining heat.
7. Some alloys less susceptible to radiation absorption.
8. More alloys available than some other metals, allowing a particular alloy to be related to a particular part.
9. Less price fluctuation on raw materials.
10. Stock readily available. Size range broad and well stocked at distributors throughout the country.
11. New procedures in producing aluminum screw machine stock now give greater tool life and higher production. New processes such as Electrofilming and Kanigen Coating also have overcome old problems such as galling and binding.
12. Technical literature for designing purposes readily available.

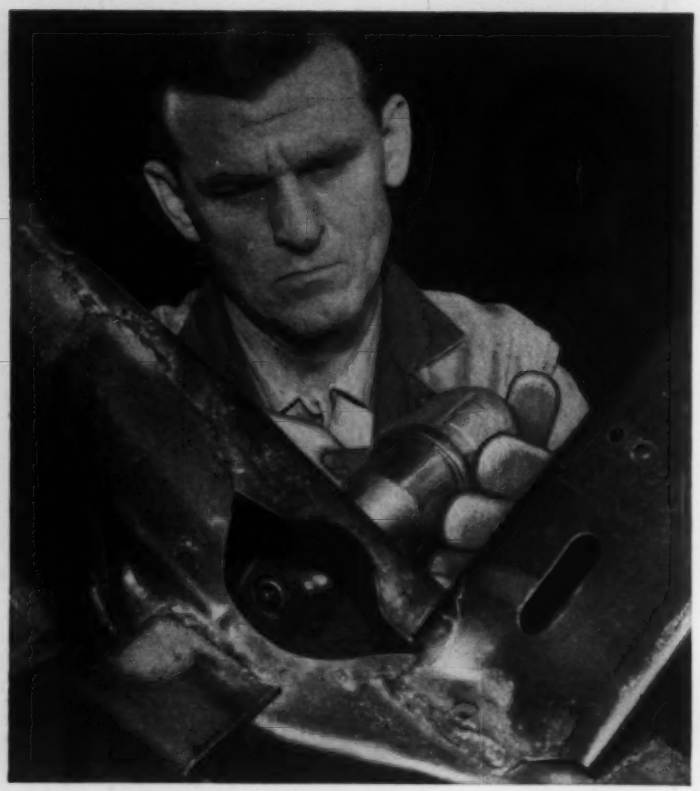
For further information and expert assistance, call the Kaiser Aluminum sales office or distributor listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *Executive Office*, Kaiser Bldg., Oakland 12, California; *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois.

See "MAVERICK", Sunday Evenings, ABC-TV Network. Consult your local TV listing.

For The Competitve Edge, Go Aluminum

KAISER ALUMINUM

THE BRIGHT STAR OF METALS



Specify MIDLAND

WELDING NUTS

for those hard-to-reach spots

Whether you're designing or fabricating, check your fastenings. Are they in hard-to-reach places? Does assembly take two men? Those are the spots for Midland Welding Nuts.

Midland Welding Nuts take seconds to apply, yet they save hours in assembly time. And, they're a better fastener. Spot welded into place for the life of the product, Midland Welding Nuts can't come loose or cause annoying rattles.

Want cost and time-saving tips? Send for the free booklet showing you how to "Save with Midland Welding Nuts."

MIDLAND-ROSS CORPORATION

WELD NUT DIVISION

6660 MT. ELLIOTT AVENUE • DETROIT, MICHIGAN

(Continued from Page 179)

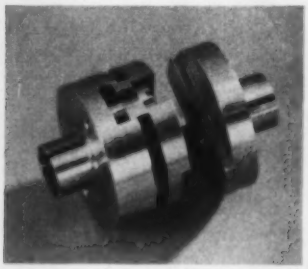
ratings in the circuits. Three standard Jetec eight-pin bases are available, with choice depending on number of rectifier cells in potted circuit. **Semiconductor Products Dept., General Electric Co.,** Electronics Park, Syracuse, N. Y. C

Circle 668 on Page 19

Coupling

for servo transmissions and high-torque drives

New Oldham-type coupling consists of two male hubs, which are fastened to the shafts to be coupled, and a floating female center section. Female connecting portion is permanently attached to one of male sections to simplify assembly. Unit is applicable in servo transmissions and similar drives where relatively



high torques are involved. Coupling surfaces are hand lapped to give minimum backlash and uniform contact. **Instrument Div., Sterling Precision Corp.,** 17 Matinecock Ave., Port Washington, L. I., N. Y. D

Circle 669 on Page 19

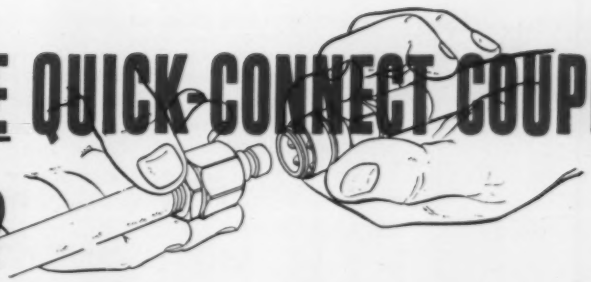
Elastomeric Adhesive

produces high-strength bonds between a variety of materials

Designated EC-1368, a new elastomeric-base, light-colored adhesive produces high-strength laminates with plastic, steel, aluminum, wood, and other materials without heat or pressure. It can be used in industrial operations and for nonload-bearing sandwich-panel construction in which plastic, steel, or aluminum facings are bonded to paper honeycomb cores. Variety of plastic-coated fabrics can also be bonded with the adhesive to rigid subsurfaces, including steel, aluminum, and wood. Bonds have high dead-load shear strength, high peel

Circle 505 on Page 19

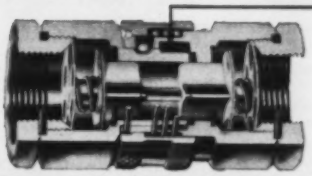
WHICH SNAP-TITE QUICK-CONNECT COUPLING IS BEST FOR YOU?



SNAP-TITE "H" COUPLING . . . . . FOR HIGH PRESSURE APPLICATIONS

FOR HYDRAULIC OR AIR

"H" Coupling for high strength, higher efficiency, high-resistance to heavy line surge. Sizes: ⅛" thru 12". Bulletin No. 240

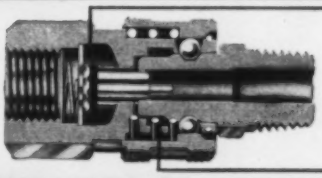


Exclusive U-packer gives a positive seal without compression set because of rubber distortion. Line pressure inside the U-packer keeps it open and forced against its metal backing—the higher the pressure, the tighter the seal.

SNAP-TITE HI-FLOW COUPLING . . . FOR LOW PRESSURE APPLICATIONS

FOR AIR AND FLUIDS UP TO 150 p.s.i.

Hi-Flow is recommended to connect small air tools to plant air system, and for low pressure fluid transfer in small lines.
Sizes: ⅛" thru ¾". Bulletin No. 230

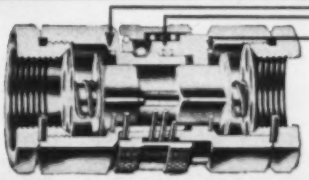


Bonded valve washer
(pat. pending on valve construction)

Exclusive U-packer

SNAP-TITE "HK" COUPLING . . . . . FOR HARD TO HANDLE FLUIDS

FOR FUMING ACIDS, ALKALIES, SOLVENTS, AND HIGH PRESSURE STEAM . . . "HK" is the only coupling now on the market for fluid temperatures from —100° F to +500° F . . . and for live steam up to 460° F. Its seals are made of Teflon for which there is no known solvent.
Sizes: ½" thru 3". Bulletin No. 270



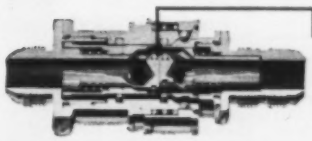
Teflon Valve Seal

Teflon Nipple Seal

Teflon Valve Seal

SNAP-TITE NO-SPILL COUPLING . . . FOR MINIMUM AIR INCLUSION

FOR AIRCRAFT, MISSILE HYDRAULIC, FUEL SYSTEMS which cannot stand air in the lines, and for transmitting fluids which *must not spill*, the Snap-Tite no-spill coupling is recommended. Bulletin No. 280

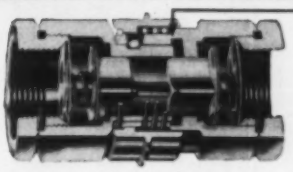


Flush valves prevent spillage, air inclusion. Snap-Tite will engineer special variations to your requirements.

SNAP-TITE "E" COUPLING . . . . . FOR VACUUM and VERY LOW PRESSURE

FOR VACUUM SYSTEMS IN THE MICRON RANGE

"E" Coupling performs in the *micron* range in the smaller sizes both connected and disconnected. Recommended, too, for gravity flow . . . U.L. approved for LP Gas.
Sizes: ⅛" thru 12". Bulletin No. 250



Nipple seals in coupler by depressing the lip of the E packer and slightly compressing the body of the packer. This new E-packer gives positive seal under high-pressure, low-pressure, and vacuum.

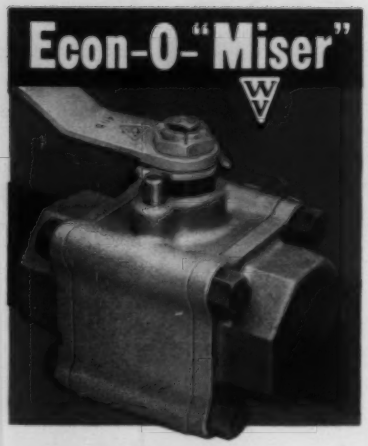
Snap-Tite Couplings are available plain, (without valves), and with either single or double shut-off. Couplings normally furnished in alloy steel, but all (except hi-flow) are also available in brass, aluminum, or stainless steel with a variety of finishes.

SNAP-TITE, INC., UNION CITY 11, PA.

Snap-Tite

SNAP-TITE COUPLINGS CAN HANDLE ALMOST ANYTHING THAT FLOWS

Circle 506 on Page 19



Worcester's New Econ-O-"Miser" Ball Valve* is BOTH

VALVE and UNION

The costs of a union and installing it are eliminated. Add to this the longer operating life of the Econ-O-"Miser", the time and materials savings of *in-line maintenance*, and you get performance unmatched by *any* valve at *any* price.

The Econ-O-"Miser" is available in Bronze, Aluminum, Aluminum Bronze, Forged Carbon Steel, types 303 and 316 Stainless Steel. Seat and seal materials available: Teflon, Buna-N and Neoprene (others available on request.)

The many combinations of body and seat seal materials allow handling of exceptionally wide range of media.

Other Outstanding Features

- Compact for ease of installation
- Positive leakproof shut-off
- **In-line maintenance** permits quick, easy inexpensive repairs
- Two-way flow allows application of pressure or vacuum to either side of valve
- Quarter turn operation — readily adaptable to remote control
- Visual determination of OPEN — CLOSED positions — No manual check needed
- Round flow through the valve — minimum pressure loss and turbulence
- "Wiper-action" of resilient seat against ball eliminates abrasive wear due to foreign materials in media . . . assures leak-proof seal . . . long operating life

* Pat. Pending

Write for full particulars

WORCESTER VALVE CO., Inc.

18 Parker Street, Worcester, Mass.

Circle 507 on Page 19

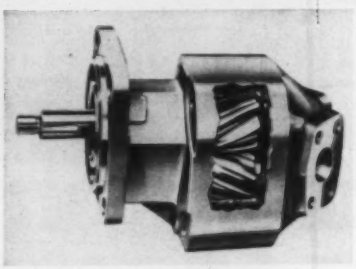
strength, and excellent resistance to cold flow. Adhesive also has good water resistance and retains strength and adhesion at temperatures over 200 F. **Adhesives & Coatings Div., Minnesota Mining & Mfg. Co.**, 423 Piquette Ave., Detroit 2, Mich. H

Circle 670 on Page 19

Hydraulic Pump

is high-speed, rotary-gear unit

Hydroid hydraulic pump incorporates gears with an elliptical profile that eliminates trapping of liquid between teeth, permitting speeds over 4000 rpm with hydraulic pressures of more than 1500 psi. Flow rates from 3 to more than 250 gpm are available for specific applications. Ability to operate at high speeds eliminates need for reduction-gearing accessories on hydraulic applications. **Hupp Aviation Co., Div., Hupp Corp.**, 6633 W. 65th St., Chicago 38, Ill. J

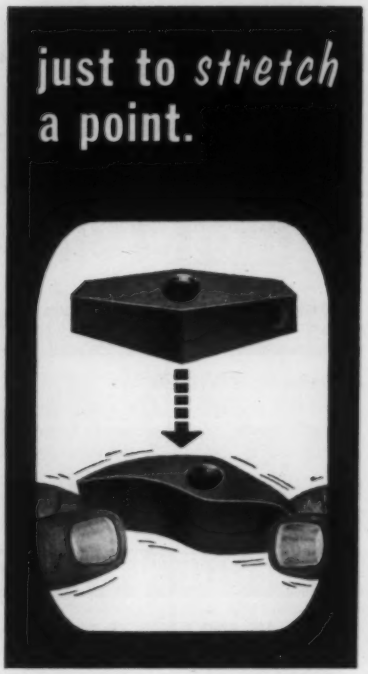


Circle 671 on Page 19

Predetermined Counter

operates at up to 450 counts per min

Tally 1000 predetermined counter is applicable to many industries and machines where positive counting is required for packaging, batching, cutting of specific lengths, and controlling of sequential operations. Unit is actuated by any type of single-pole, single-throw switching device. Counting speed is up to 450 counts per min, with counter selectivity of 1 to 1000. Operator sets desired selectivity directly, and unit recycles automatically to zero when complete count has been made. It can also be stopped from recycling automatically and is reset manually by pushbutton. Operating voltage



. . . Next time specify

INVESTMENT CASTING

Parts design becomes as flexible as wax when you specify Investment Casting. Because with this "lost wax" process, parts can be designed for function; for utmost operating efficiency rather than compromised to satisfy a method of manufacture.

Costly machining and assembly operations are reduced and often eliminated. Complex and time consuming tooling setups too! And — you have the widest selection of alloys from which to choose: the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels . . . even cobalt base alloys.

Thus you stretch your design potential, you stretch your range of metals and you stretch your budget when you specify this process.

It might stretch your imagination too, if you could see some of the intricate shapes we're casting here at Hitchiner. If you'll write us today for our free new brochure, you'll get an idea how you can utilize the freedom and savings offered with Investment Casting.

HITCHINER

MANUFACTURING COMPANY, INC.

MILFORD 14, NEW HAMPSHIRE

Representatives in Principal Cities

Circle 508 on Page 19

NOSCO "CAN DO"

takes mammoth projects in stride

Take the case of Gould-National Batteries, Inc. After personal inspection of many plastic molding plants, evaluating engineering personnel and facilities, Gould selected Nosco to produce a new line of ten stationary battery containers and their covers. Nosco "Can Do" started by assigning an experienced sales-engineer to supervise and coordinate the program and report progress to Gould every two weeks. Twenty molds were completed in little more time than is usually required to produce one . . . from drawing board through chrome plating. Nosco molded the containers of acrylonitrile, running several molds simultaneously on giant pre-plasticized presses. The molded pieces were annealed a truckload at a time, and decorated by an ingenious method which avoided duplication of screens. Finally, these parts received comprehensive approval by Western Electric inspectors.

The Gould-National contract is one more indication of the scope of Nosco "Can Do". More than service, engineering, and production know-how, Nosco "Can Do" includes the financial ability to carry large tooling and warehousing programs.

When awarding your large plastic parts program, call on Nosco "Can Do".

The first step is to write—

For other case histories—and for a glimpse of the Nosco plant and facilities, send for the free 12-page brochure, "How the Nosco Plant Works to Produce Your Needs in Practical Plastics."

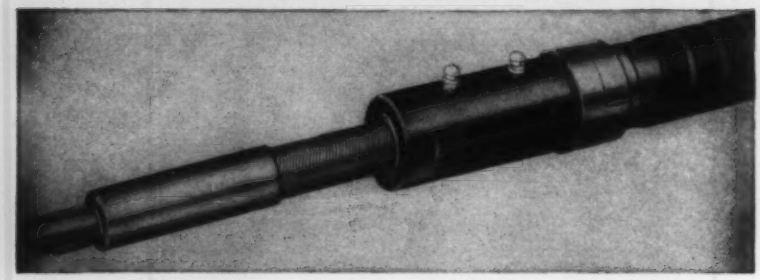
NOSCO plastics, inc. • erie 2, pa.

World's largest injection molding plant

Circle 509 on Page 19

STOW FLEXIBLE SHAFTING
The Ideal PTO Drive

1¼" flexible shaft under tractor-trailer transmitting 10 HP.



1¼" core assembly pulled out of casing. Note steel-backed bronze sleeve bearing.

Here are five big reasons why flexible shafting is an ideal power take-off drive on trucks and tractor trailers.

FLEXIBLE SHAFTING:

1. Can connect a drive shaft and a driven shaft which are working at different angles and located in different planes.
2. Eliminates the need for accurate alignment.
3. Eliminates dangerously exposed revolving parts; no safety guards required.
4. Replaces connections affected by vibration.
5. Is economical because it is so easy to install and maintain.

Available with built-in bearings and couplings in sizes from ¼ inch to 1¼ inches in diameter—STOW flexible shafting can help solve your trucking and maintenance problems *in advance.* The know-how of 82 years' experience goes into every STOW flexible shaft!

STOW flexible shafts are being used on trucks and tractor-trailers to:

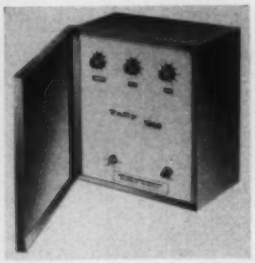
- Operate pumps for petroleum, other liquids and hydraulic pumps on dump trailers.
- Operate conveyors for grain and coal.
- Operate compressors on refrigeration trucks.

Our Engineering Department will be glad to work with you on any special drive problems. For complete data on flexible shafting sizes, torque capacities, and other specifications, write for STOW Engineering Bulletin, No. 570, and Tractor-Trailer Bulletin, No. 542.

STOW

STOW MANUFACTURING CO.

11 Shear St. Binghamton, New York



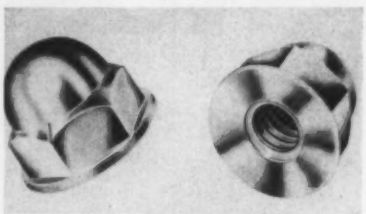
is 115 or 230 v, 60 cycle ac; power consumption is 25 w. **Hobson Miller Machinery Corp.**, 280 Lafayette St., New York 12, N. Y. D

Circle 672 on Page 19

Threaded Cap Nut

has integral washer base

New threaded cap nut, die cast from zinc alloy, has an integral washer base, eliminating the need for a separate washer. Washer base provides greater mating area so that unit has a firmer grip on surface, and aids in preventing loosening of assembled parts. The nut can be used without damage to soft surfaces such as plastic, wood, or composition board. Nut is available from stock in closed-end, ⅜-in. hex size. Other sizes and types, with various washer-base diameters and



thicknesses, will also be available. Nut is durable, rustproof, and corrosion resistant. **Gries Reproducer Corp.**, 400 Beechwood Ave., New Rochelle, N. Y. D

Circle 673 on Page 19

Indicator Light

for use on exposed panels

Series L5100 moistureproof miniature indicator light is for use on shipboard, aircraft, and other exposed panels. Unit contains two recessed rubber O-rings that afford a watertight fit between lens cap and case and between mounting flange and panel. Lens cap is available in over ten transparent

Circle 510 on Page 19

here's how Crucible Fatigue-Resistant Springs are made stronger to last longer

Crucible *fatigue-resistant* springs outlast conventional heavy-duty coil springs many times. That's because they are shot peened.

Shot peening actually makes the springs stronger by imposing a compressive stress on the surface of the spring that offsets some of the working stresses set up in service. Further, shot peening conditions the surface. The high intensity peening eliminates stress concentration points that could lead to failure of a conventional spring.

Moreover, when you buy Crucible springs, you employ all of Crucible's many years of experience and metallurgical know-how in fine steelmaking – from ore to finished spring. Good springs demand the best in specialty steels. During manufacture, quality checks are made continuously. And a final magnetic test may be given if desired.

When you have a requirement for a spring that must endure rugged operating conditions, secure the built-in advantages of Crucible *fatigue-resistant* springs. And for technical assistance in designing or selecting heavy-duty springs, don't hesitate to consult with Crucible's spring specialists. For a free copy of a handbook on "Coil Spring Design," write to *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE HEAVY-DUTY COIL SPRINGS

WORLD BESTOS BRAKE LINING

... any *shape* ... any *size* ... any *friction* to meet your most exacting requirements!

ROUND

as for Race Cars

INTRICATE

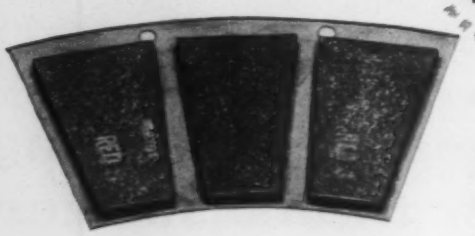
as for Industrial Brakes

TINY

as for small Precision Assemblies

BIG

as for giant Forming Presses



● World Bestos is currently helping many manufacturers solve difficult braking problems with special friction formulas that assure dependable stopping power, non-fading performance and extra long life.

World Bestos offers extensive research and development facilities and more than 30 years' specialization in friction material manufacture. Modern, high-capacity plant assures on-schedule delivery.

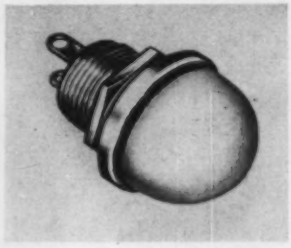
● **Write for new Industrial Brake Folder . . . or let us know your specific requirements. Send prints and specifications if possible. Engineering assistance available.**

WORLD BESTOS NEW CASTLE INDIANA

DIVISION OF THE **Firestone** TIRE AND RUBBER CO.

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

and translucent colors. Unit accommodates midget flange base AN3140 lamps, which are available for 6, 14, or 28-v operation. Case is corrosion-resistant anodized



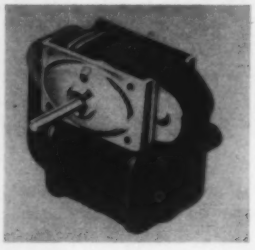
aluminum. Only 1 9/64 in. long, light mounts in a ½-in. panel hole. **Hetherington Inc.**, Folcroft, Pa. E

Circle 674 on Page 19

AC Motor

has horsepower ratings to 1/150 hp at 2400 rpm

Type B precision-made ac motor has long-life alignable bearings, large oil reservoirs, starting torque to 0.215 lb-in., and low noise level. Stack thicknesses of 9/16 and 15/16 in. and shaft diameters of ⅛ and 5/32 in. are available. Horsepower ratings extend to 1/150 hp at 2400 rpm. Typical applications include driving fans for slide projectors, desk fans, heaters, deodorizers, and elec-



tronic equipment, use as blower for refrigerators and hair dryers, and driving gear trains for vending machines, appliances, and office machines. **Barber-Colman Co.**, Rockford, Ill. K

Circle 675 on Page 19

Cam-Follower Bearings

for cam-activated and similar mechanisms

Full-type cam-follower roller bearings provide high radial load-carrying capacity and shock resistance for cam - activated and similar

Circle 512 on Page 19

Circle 513 on Page 19→

Got a Real Tough Starting Problem ?

Single-phase Type RA ½ to 15 hp.

Wagner Repulsion-Start Induction Motors start heavy loads with low current

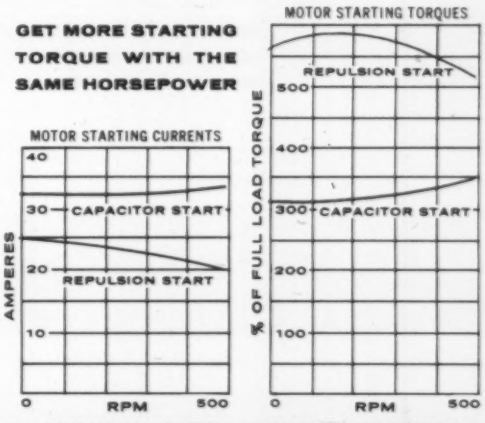
The Wagner Type RA is the work-horse of the single-phase motor field. It combines high starting torque for quick, easy starts with low starting current and minimum light flicker. It has a constant high operating speed, even under overload, and a flat efficiency curve over a wide operating range.

You practically eliminate service problems when you power tough single-phase applications with Wagner RA Motors. They have unmatched ability to start high inertia or heavy friction loads repeatedly and they give many years of unfailing service.

Let a Wagner Sales Engineer show you how these motors can be applied to your needs. Call the nearest branch office or write for Bulletin MU-220.

Wagner Electric Corporation
6400 Plymouth Ave., St. Louis 14, Mo.
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

GET MORE STARTING TORQUE WITH THE SAME HORSEPOWER



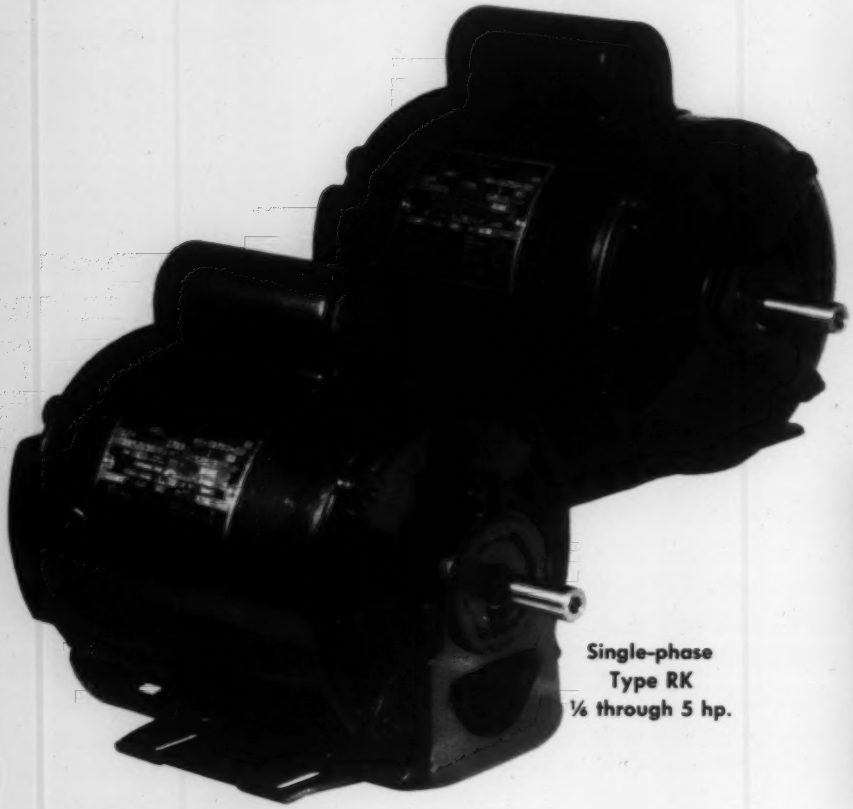
ONE HP, 1750 RPM, 60 CYCLES, 230 VOLTS

Integral Ratings, 1-5 hp are available in the latest NEMA Frame Sizes

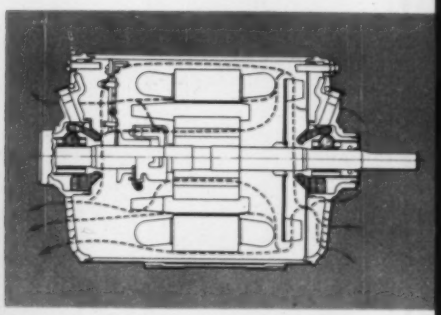
H. P.	OLD FRAME SIZE	PRESENT FRAME SIZE
1	203	182
1½	204	184
2	224	213
3	225	215
5	254	254U

4 pole (1750 RPM, 60 cycle and 1450 RPM, 50 cycle) ratings are interchangeable in mounting dimensions with capacitor start motors of the same ratings.

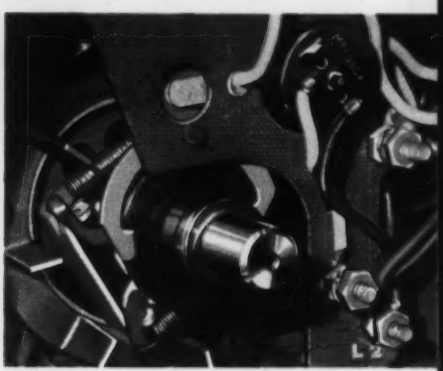
Got a Normal Starting Application?



Single-phase
Type RK
⅙ through 5 hp.



EFFICIENT COOLING SYSTEM—The improved ventilating system used in these motors directs a large volume of air through the motor to effectively reduce temperatures and add to motor life. Cross section above indicates direction of air flow.



QUICK BREAK SWITCH—The starting winding and capacitor are disconnected from the line by this Wagner Switch—test-proved to make more than a million makes and breaks . . . the equivalent of two starts per hour for 50 years.

MYLAR* INSULATION — Mylar-paper laminated slot insulation gives top protection against moisture, adds thermal stability, to give more application versatility and longer life when unexpected overloads occur.

*DuPont Trademark

WAGNER CAPACITOR-START MOTORS provide dependable starts... long troublefree life

Here's the single-phase general purpose motor that gives more horsepower with less bulk—is rugged enough to permit direct mounting, compact enough to fit in tight spots. Available with sleeve or ball bearings — with rigid bases or with resilient mountings for exceptionally quiet operation.

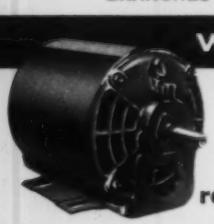
ALL-ANGLE OPERATION

The sleeve bearing design in fractional hp ratings, has a positive lubrication system that permits operation in any position. All angle mounting can mean important savings in initial costs to manufacturers—can help the design engineer in a tight spot.

You can get these motors from leading motor distributors in your community and from Wagner Sales Offices in 32 principal cities. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details.

Wagner Electric Corporation
6400 Plymouth Ave., St. Louis 14, Mo.
BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

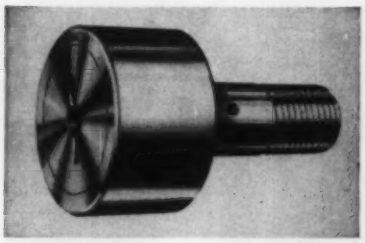
WAGNER "48" SPLIT PHASE MOTORS . . . 1/6, 1/4, 1/3 hp.



for low starting torque requirements

If you need a small fractional horsepower motor for use on fans and blowers or on a wide variety of easy-to-start machines and appliances, you can't beat the Wagner "48" Type RB Motor. It offers all the advantages of the Type RK described above, with the exception of high torque capacitor starting. This smaller, lighter, limited use motor can solve many application problems economically.

WM58-8



mechanisms. Units are available with either standard studs, or with heavy-duty studs which provide greater shear resistance where severe operating conditions exist. Seals can be provided for special applications. There are 22 standard sizes from ½ to 4 in. OD in plain steel, chrome and cadmium plating, or black oxide finish. **Orange Roller Bearing Co. Inc.**, 557 Main St., Orange, N. J. D

Circle 676 on Page 19

Selenium-Rectifier Stacks

provide up to 21,000 v peak inverse voltage

High-voltage selenium-rectifier cartridge stacks incorporate extra-thin base plates on which selenium is deposited. Cartridges provide up to 21,000 v peak inverse voltage. New voltages are available in current ratings of 5, 10, and 17 ma (capacitor loads). Containers, either glass

tube and ferrule, or phenolic tube, are hermetically sealed for continuous operation in salt, fog, and other adverse atmospheric conditions. **Syntron Co.**, 260 Lexington Ave., Homer City, Pa. F

Circle 677 on Page 19

Super-Alloy Tubing

shows excellent strength at high temperatures

During a 1000-hr test period, new line of super-alloy tubing, comprising 16 different analyses, failed to rupture under a stress load of 25,000 psi at 1200 F. Tubing resists oxidation and other types of

Circle 514 on Page 19

SMART ENGINEERS GET FAST RECOGNITION BY...

MAKING MANAGEMENT TAKE NOTICE

with cost reducing ideas saving up to 70% by using LOCTITE in place of sems, lock washers and other mechanical locking devices.

GIVING PURCHASING SOMETHING TO SHOUT ABOUT

by eliminating stocking a wide array of shapes and sizes of locknuts and washers. LOCTITE Liquid Sealant "fits" all threaded parts—and a bottle goes a long, long way.

TAKING THE HEADACHES OUT OF PRODUCTION

by eliminating press fits, staking, and high-driving torque tightening . . . permitting looser tolerances, reducing rejects and speeding production.

• • • •

LOCTITE treated fasteners come off *only* when you *take them off* . . . giving maximum product reliability. Four strengths provide any required locking torque. LOCTITE seals against oil, military fuels, gases under high pressure.

Write for complete details.

LOCTITE® SEALANT
AMERICAN SEALANTS COMPANY
111 Woodbine St., Hartford 6, Conn.

Circle 515 on Page 19

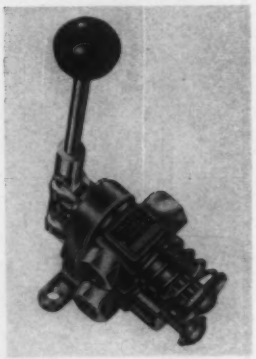
corrosion. Alloys retain base hardness, show no excessive grain growth at operating temperatures, and elongate before fracturing when overloaded. Both seamless and welded and drawn tubing is furnished in size range of 0.012 to 1.125 in. OD. **Superior Tube Co.**, 1578 Germantown Ave., Norristown, Pa. C

Circle 678 on Page 19

Control Valves

three and four-way units are tandem mounted

Lever - actuated, tandem - mounted, three and four-way control valves with neutral position are designed for up to 250 psi pneumatic and 325 psi oil or vacuum service. Manual or spring-actuated neutral positioning is available. Tandem valve is interlocked to prevent both valves from operating simultaneously. Valves provide leakfree service and unrestricted flow capacity. Available with open-end or piped exhaust, units are offered in port sizes from ¼ to 1 in. NPT. **Valvair Corp.**, 454 Morgan Ave., Akron 11, Ohio. F

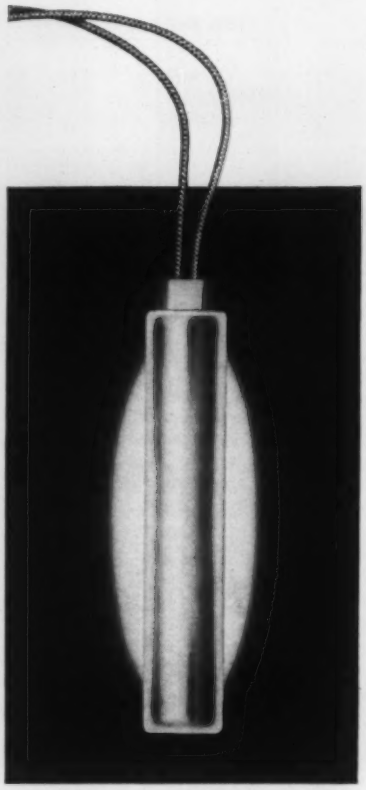


Circle 679 on Page 19

Ball-Bearing Screw

miniature unit has 3/16-in. ball-circle diameter

Miniature, lightweight ball-bearing screw has applications in electronic controls, radar tuners, missile and rocket guidance and telemetering systems, automatic switching devices, electronic machinery controls, and others where critical positioning and control problems are encountered. Unit, which has only 3/16-in. ball-circle diameter, operates at near maximum efficiency



up to 5 times more Heatpower

CHROMALOX REDHEAD

Electric Cartridge Heaters

More heat in the same space—up to 5 times as much as standard cartridges.

Faster heat-up—up to 5 times faster.

Faster cycles—Redheads recover up to 5 times faster.

Last longer—Greater capacity makes "hard" jobs easy. Special construction stands up better under rough usage.

Exclusive construction — Highest quality nickel-chromium resistor wire coiled around special ceramic core, centered in refractory material with highest heat transfer ability. Inconel sheath combines fast heat transfer with resistance to high temperature corrosion. Flexible lead wires of standard manganese-nickel are covered with special high temperature insulation.

85 to 4600 watts . . . 120-240 volts
Diameters range from ⅜" to ¾"
Lengths from 1⅛" to 24"

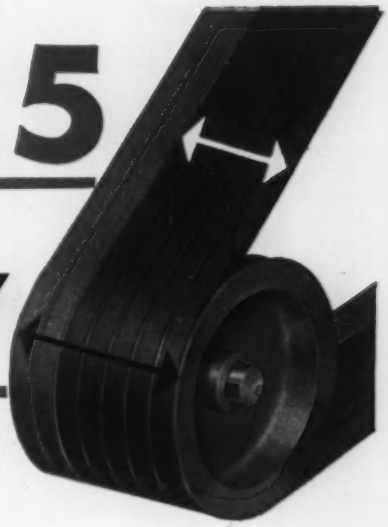
If your job for cartridge heaters is one of the very few requiring even higher wattages, check with your Chromalox Sales-Engineering Representative—the "Man with the Answers" to all your heating problems.

Write for Bulletin 997. 2643

CHROMALOX Electric Heat
Edwin L. Wiegand Company
7575 Thomas Boulevard • Pittsburgh 8, Pa.

Circle 516 on Page 19

Drive with 5 instead of 7



Use fewer V-belts... get equal horsepower
Save space and costs

You cut sheave width and weight . . . you save in overall costs . . . by using Gates Super Vulco Ropes with 40% more HP capacity. Five Supers actually do the work of 7 standard V-belts.

For that reason, a Super Vulco Rope Drive delivers more HP per dollar invested than any standard V-belt drive.

Sheaves with fewer grooves cost less . . . weigh less . . . occupy less space. Your drive design is greatly improved.

You can get helpful drive data quickly. Just call your nearby Gates distributor for advice from a Gates V-Belt Specialist.

Stocks carried in industrial centers throughout the world.

Gates Distributors are in the Yellow Pages

The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

Gates — The Mark of Specialized Research

No other V-Belt has ALL these advantages

1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life...more power available to driven machine.

2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.

3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads... reduce number of belts required... save weight and space.

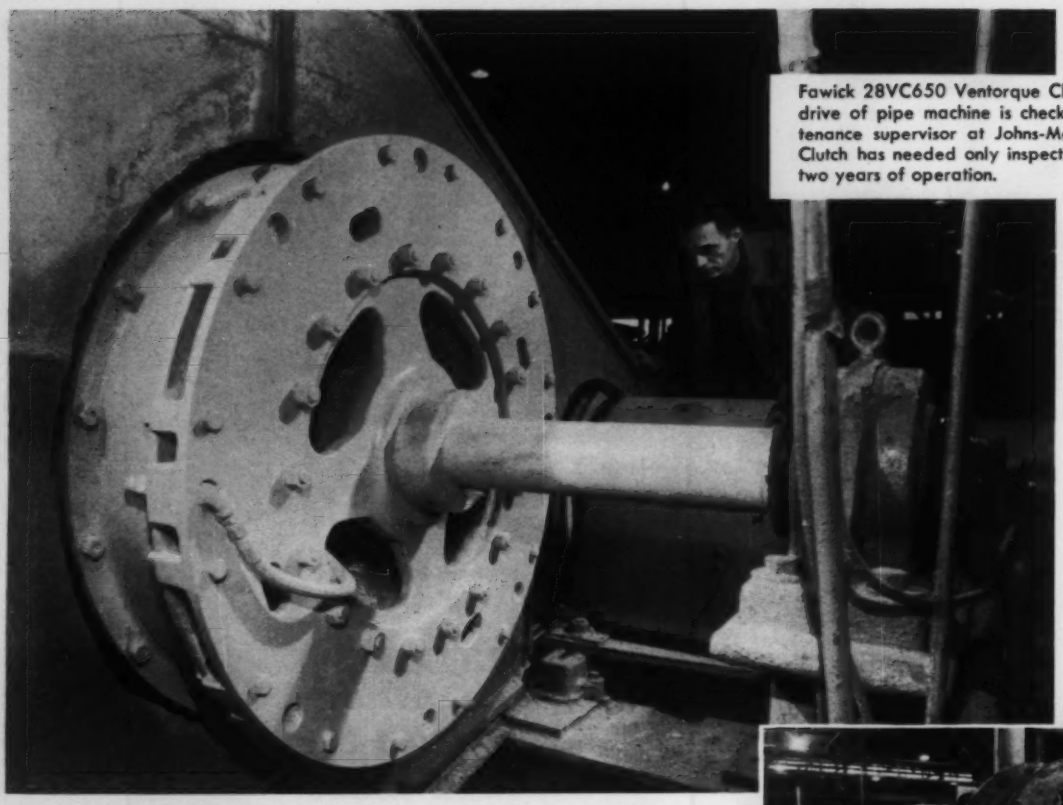
4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 306

Gates Super Vulco Rope Drives

40% more Horsepower Capacity



Fawick 28VC650 Ventorque Clutch on main drive of pipe machine is checked by maintenance supervisor at Johns-Manville plant. Clutch has needed only inspection during its two years of operation.

Like Johns-Manville Transite Pipe Plant, you can...

use Fawick Clutches to improve machine performance and reduce maintenance costs

Fawick 11.5VC500 Ventorque Clutch locks press roll on pipe machine to desired pressure for special Transite pipe production. Precise operation despite heavy dust load helps machine keep pace with production schedules.

Machines producing Transite pipe give clutches a rough going-over: sudden, high-impact starting loads . . . rapid build-up of abrasive cement and asbestos dust . . . accurate cycling requirements . . . 'round-the-clock operation six days a week. Tougher conditions would be hard to imagine. Yet, FAWICK Airflex Clutches at Johns-Manville deliver dependable performance and meet increasing production demands with no maintenance or downtime. Some have been installed for over six years with only routine inspection.

Reasons for this record lie in the design of FAWICK Clutches:

- operation of FAWICK Drum Type Clutch unaffected by foreign material.
- durable drum-type construction takes years of punishment.
- rubber air tube cushions operating shocks.
- self-adjusting friction shoes automatically compensate for wear.
- mechanical linkages have been eliminated to provide smoother, more accurate operation.

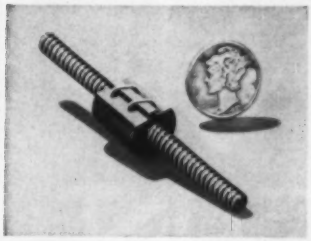
These are the proof—for long clutch life and trouble-free service, you can't beat a FAWICK Clutch. For more information, contact your nearest Fawick representative or the home office.

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION

9919 CLINTON RD. • CLEVELAND 11, O.
In Canada, Fawick Canada, LTD., Toronto

FAWICK Airflex

INDUSTRIAL CLUTCHES AND BRAKES



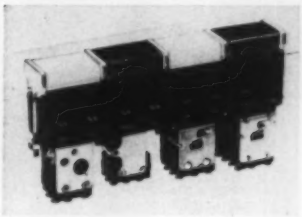
at temperatures as low as −65 F. Unit will position components to within 0.0005-in. per in. travel. **Saginaw Steering Gear Div., General Motors Corp.**, Saginaw, Mich. H

Circle 680 on Page 19

Pushbutton Switches

incorporate two built-in indicator lights

Series 100 PB modular-mount lighted pushbutton switches are available in two, three, and four-pole units, in alternate-action, light-force, and positive touch-feedback designs. Each unit incorporates two miniature, built-in indicator lamps which provide flexibility of indication. Pushbuttons can be removed and replaced from panel front. They



are available in either single or two-color types. Assemblies accommodate panel thicknesses from 0.094 to 0.125 in. **Micro Switch, Div., Minneapolis - Honeywell Regulator Co.**, Freeport, Ill. K

Circle 681 on Page 19

Temperature Control

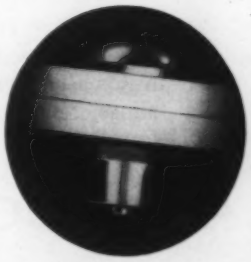
is sensitive, remote-bulb unit

Explosionproof, dual-switch temperature control, designated D98A, is a sensitive, remote-bulb unit designed for use in hazardous locations where explosive vapors and gases are present. Two separate switches permit switch action above or below set point, control of two independent circuits, and flexibility of switching arrangement. Tem-

Townsend lockbolts* give the designer great flexibility, for they may be used in either shear or tension applications, and have great resistance to fatigue. A high tensile pre-load is imparted to the joint during installation, which gives a very high shear value. No overdesign is necessary, because shear and tensile pre-load values are the same in every joint.

The setting gun swages the collar to the locking grooves on the pin, and breaks off the projecting pin tail as a pre-determined break-load is reached. The gun's cycling action cannot be altered, and even men with no special skill can produce strong, uniform, economical joints.

For more information on Townsend lockbolts, request a complete demonstration right at your desk, or write for Bulletin TL-101. Townsend Company, P. O. Box 237-E, New Brighton, Pa.



*Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

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Sales Offices in Principal Cities

Circle 519 on Page 19

NEW RAWSON

Automatic Centrifugal Clutches and Clutch Couplings

The secret* behind the ability of RAWSON CLUTCHES to provide fluid smooth starts to high inertia loads.

The new Rawson, manufactured under the original Rawson Patents, incorporates *exclusive metallic shoe segments* for 100% power, trouble-free operation and longer life. These metallic shoes effectively control dissipation of heat energy; thus, the clutch easily absorbs the torture usually imposed on the prime mover, eliminates need for costly reduced-voltage starting equipment, and permits use of smaller motors to start high-inertia loads.

Completely automatic and entirely mechanical in operation, all Rawson clutches and clutch couplings provide full overload protection, never need adjustment.

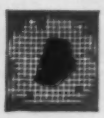
SEND NOW FOR NEW CATALOG. For complete facts and specifications on the full line of Rawson Automatic Centrifugal Clutches and Clutch Couplings, send today for the FREE 1958 Rawson Catalog.

FORMSPRAG COMPANY

Distributorships available in selected areas. Write for details.

*Patent Pending

58RC-3

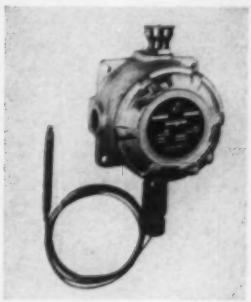


SALES AGENTS

23603 HOOVER ROAD, WARREN (DETROIT), MICHIGAN, PHONE: JEFFERSON 6-5100

Rawson Clutches and Clutch Couplings Manufactured Exclusively by Rawson Division of O. S. Walker Company

perature settings are made by rotating calibrated knob over graduated barrel. Individual adjustment of switches is accomplished by independent recessed hex-head screws. Standard head compensation is ef-



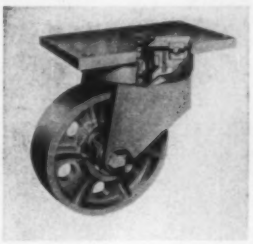
fective from −65 to 160 F. Unit is available in many switch combinations, all single-pole and suitable for 180-F ambient temperature. **United Electric Controls Co.**, 79 School St., Watertown 72, Mass. B

Circle 682 on Page 19

Precision Caster

for heavy-duty applications

Series HX300 heavy-duty precision caster provides free swivel and rolling action under loads up to 5 tons per caster. Semisteel wheel, equipped with radial and thrust bearings, is available in 8 or 10-in. diam. Adjustable, slotted nut provides for



30-deg turn lateral adjustment in swivel takeup. **Faultless Caster Corp.**, 1521 N. Garvin St., Evansville 7, Ind. J

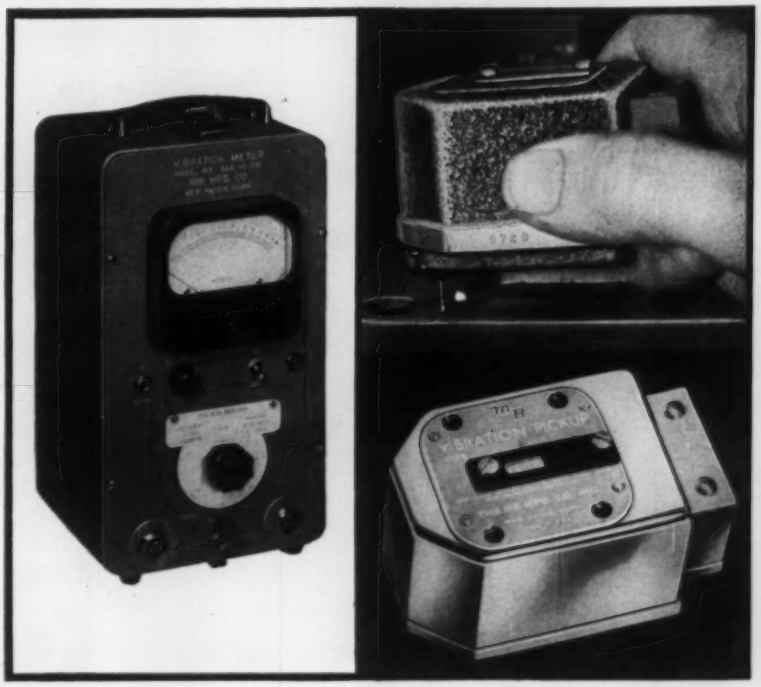
Circle 683 on Page 19

Magnetic Clutches

have torque ratings from 40 to 4000 lb-ft

New electromagnetic tooth clutches, available for machine tools, utilize form-locking principle to transmit

(*Please turn to Page 200*)



Search . . . detect . . . measure vibration

whether ***STRONG*** *or FAINT*

MB VIBRATION DETECTION SYSTEMS pinpoint vibration, help you determine its characteristics.

The MB Vibration Pickups are a first essential to any effort to eliminate vibratory motion as a source of trouble, or to correct for it. They're both sensitive and rugged — to meet testing needs for aircraft, missiles, airborne components and general laboratory.

Fixed type pickups are electrically damped, and are fastened to specimen in any position from vertical to horizontal. Probe type is hand-held for exploring large surfaces. Adding but a negligible gram of mass to the test specimen, it indicates actual resonant modes of lightweight objects.

Converting velocity into voltage, MB Pickups also provide data on acceleration and amplitude. Output can be fed into various accessories, including oscilloscope, wave analyzer, magnetic tape recorder, stroboscopes (for synchronizing light with the motion and permitting direct visual study). One of the most useful of accessories is an MB M1, M3 or M6 Vibration Meter. It gives direct readings in terms of acceleration, velocity and amplitude and accommodates several pickup inputs.

Send for detailed bulletin 412.

MB manufacturing company

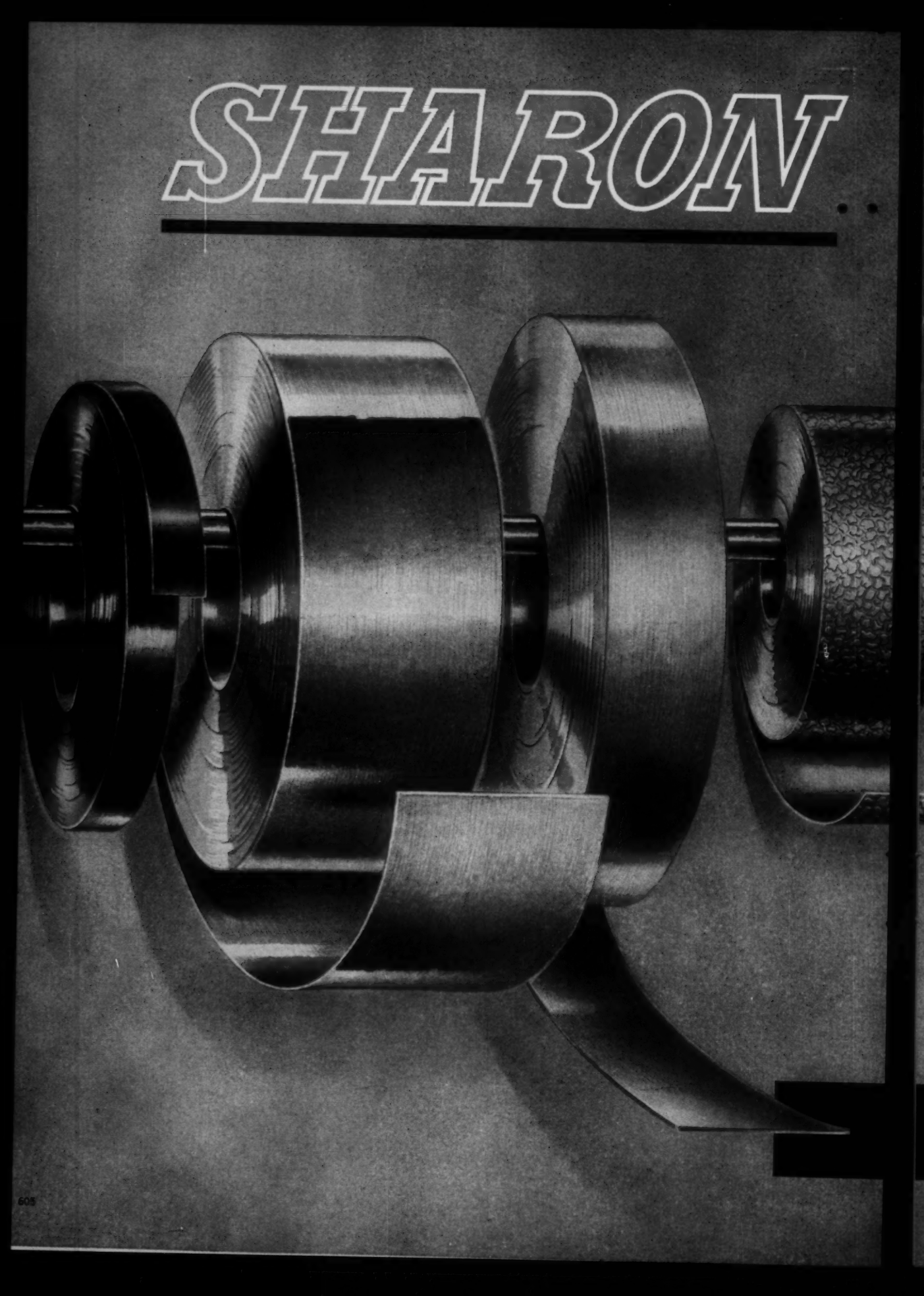
A DIVISION OF TEXTRON INC.

1056 State Street, New Haven 11, Connecticut

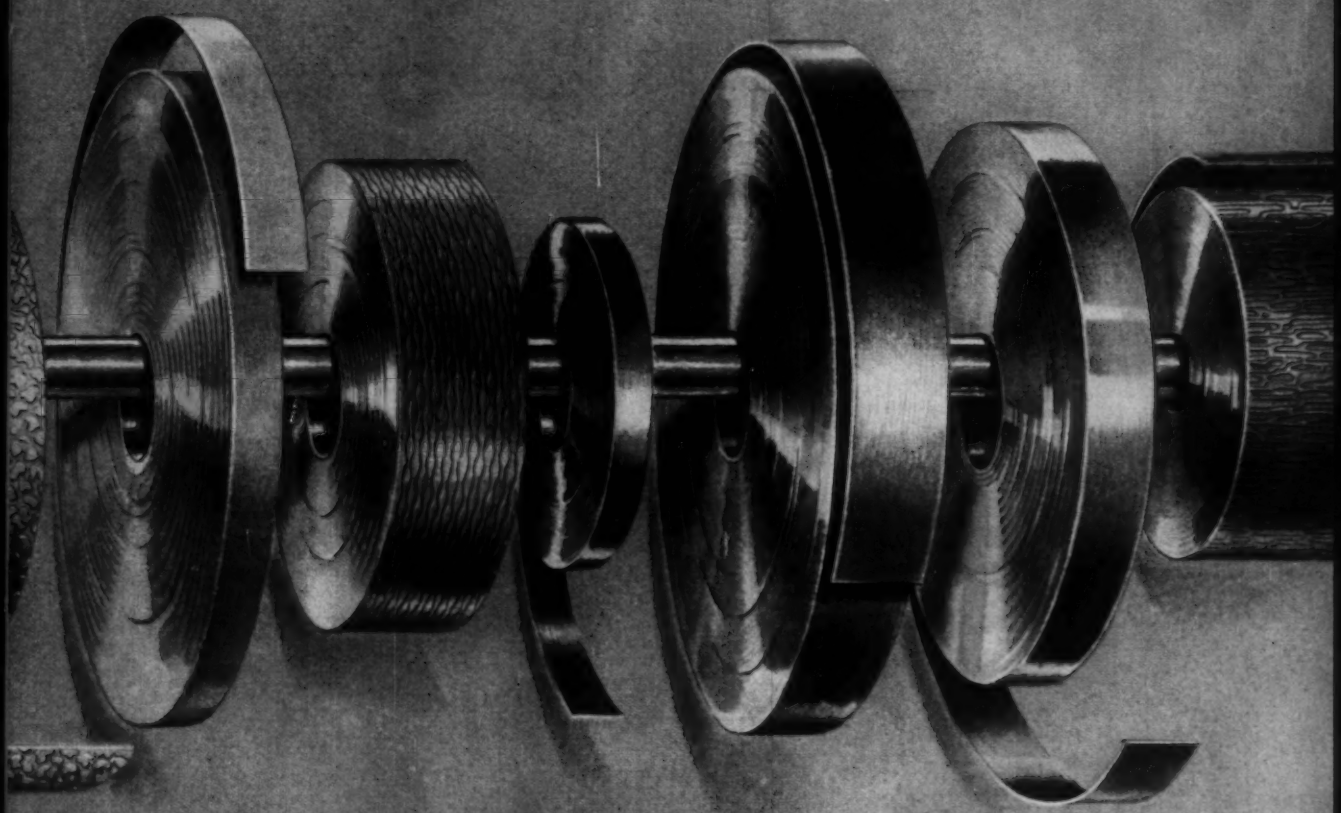
HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION

Circle 521 on Page 19

Circle 522 on Page 19→


SHARON...

. . a big name in specialty steels



For missiles or mixers, rockets or razors—whatever your steel requirements —depend on Sharon for consistent quality . . . exactly to your specifications.

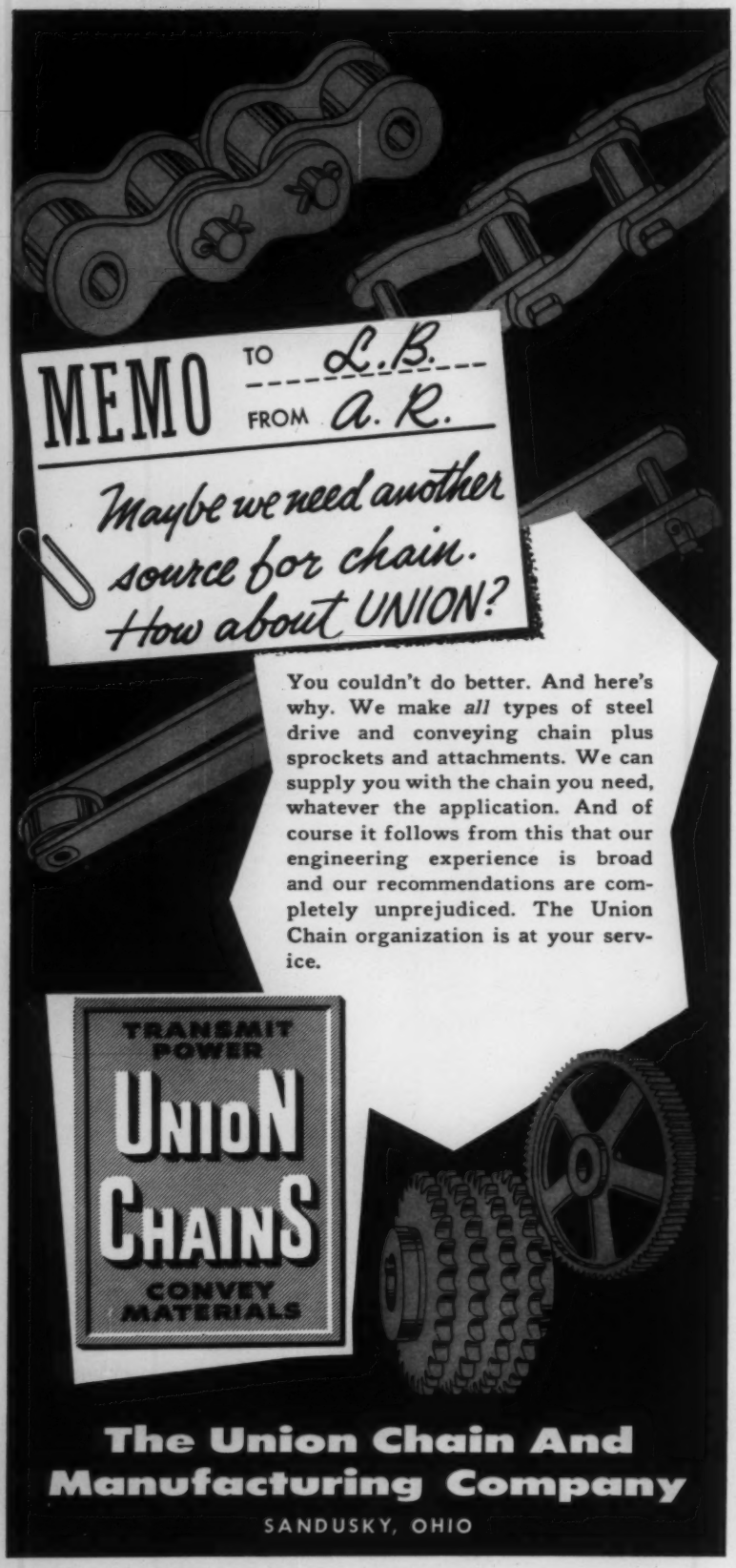
Sharon makes a complete line of chrome, chrome-nickel, chrome-manganese stainless, spring and high carbon, high tensile, coated, silicon—or any special alloy—open hearth or electric furnace, of any surface pattern, including the new rolled-in designs.

If you haven't already discovered this outstanding source of specialty steels, or the significance of Sharon Quality, make it a point to talk with a Sharon salesman at your first opportunity.

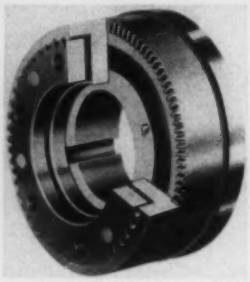
SHARONSTEEL

SHARON STEEL CORP.

SHARON, PENNSYLVANIA


MEMO TO L.B.
FROM A.R.
Maybe we need another source for chain. How about UNION?
You couldn't do better. And here's why. We make all types of steel drive and conveying chain plus sprockets and attachments. We can supply you with the chain you need, whatever the application. And of course it follows from this that our engineering experience is broad and our recommendations are completely unprejudiced. The Union Chain organization is at your service.
TRANSMIT POWER
UNION CHAINS
CONVEY MATERIALS
The Union Chain And Manufacturing Company
SANDUSKY, OHIO

(Continued from Page 197)



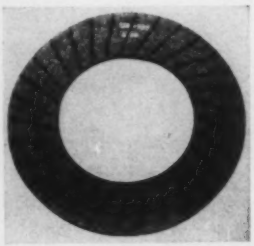
torque. Features include zero idle torque, engagement up to 300 rpm relative speed, and disengagement under full load while running at maximum rpm. Bolt-on design is accomplished through use of a simple mounting adapter. Clutches provide extremely high torque transmission with reference to overall dimensions. Clutches are available with torque ratings from 40 to 4000 lb-ft. **McCauley Industrial Corp.**, 1840 Howell Ave., Dayton 17, Ohio. G

Circle 684 on Page 19

Clutch-Facing Material

has high centrifugal burst strength

Pyrotorq clutch-facing material provides good durability and smooth engagement. It is nonwoven asbestos felt, compounded to produce desired friction range. Material has extreme-



ly high centrifugal burst strength in dry applications. **Equipment Sales Div., Raybestos - Manhattan Inc.**, Bridgeport 2, Conn. B

Circle 685 on Page 19

Socket

for Jetec 30 transistors

Body of new socket is molded from mica-filled phenolic to meet MIL-M-14, Type MEE. Unit is for use with new three and four-pin Jetec 30 transistors. Beryllium - copper

Atlas missile test tower

MISSILE LAUNCHING VALVE COST REDUCED 30% WITH ESCO CASTING

Problem: Fabricating high pressure gas tank butterfly valve bodies for missile component manufacturer Convair-Astronautics, San Diego, California, proved unsatisfactory. Consisting of wrought stainless steel flanges and tubes welded together and machined, valve costs were high. Weld seams were susceptible to intergranular corrosion and gas leakage. This was a critical installation as these units had to withstand test temperatures ranging from −65° to 500° F., at 2,000 vibrations per second and at stresses up to 15 gravity units.

Solution: The valve body was redesigned as a casting. One-piece design alloy steel improved strength and corrosion resistance and practically eliminated the danger of gas leakage. *ESCO* centrifugal casting technique permitted casting six 180-pound valve bodies simultaneously. Resulting savings in material and labor amounted to 30 per cent of previous costs.

You can simplify your design problems by calling an ESCO engineer today.

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ELECTRIC STEEL FOUNDRY COMPANY

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AUTOMATIC LUBRICATORS

For
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Consider Service—Bijur Field Engineers work hand in hand with machine builders to custom design a Bijur system which will amply meet the needs of the machine for automatic lubrication.

How you benefit—Whether you are a designer, purchasing agent, or plant engineer, you'll see substantial savings when you have Bijur Systems in the equipment you own and manufacture. Custom designed, Bijur Systems are easy to install, reduce down-time and repair bills, increase production, eliminate costly hand oiling. There's no chance for product spoilage due to over-lubrication, Bijur Systems deliver the right amount of metered oil to every bearing, *when it's needed.* Costly hand oiling is eliminated.

Write today for all the facts on how Bijur Systems can solve your lubricating problems.

BIJUR AUTOMATIC LUBRICATORS—STANDARD EQUIPMENT IN MANY INDUSTRIES
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Pioneers in Automatic Lubrication

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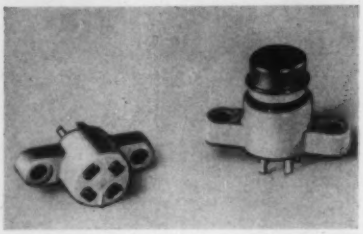
contacts are wrap-around style, silver plated and gold flashed for good contact and corrosion resistance. Contact numbers are molded into rear of socket. Key mark is



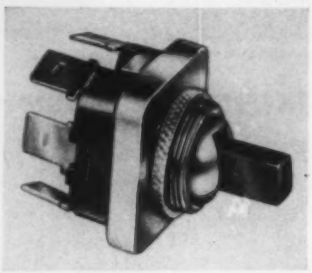
molded into top of socket for line-up with transistor case tab. Either rivets or No. 2 screws are used for mounting. **Grayhill Inc.**, 561 Hillgrove Ave., LaGrange, Ill. I

Circle 686 on Page 19

Toggle Switch

provides double-pole, three-position operation

Type 2050 flush-mounting toggle switch provides single-throw two-position, double-throw two-position, or double-throw three-position circuit arrangements. Switch is furnished with long or short phenolic toggles in black or colors. Electrical rating is 15 amp 125 v, 7½ amp



250 v ac. Terminals are supplied as binding-head screws, solder-type, or quick-connect type. **Ark-les Switch Corp.**, 51 Water St., Watertown 72, Mass. B

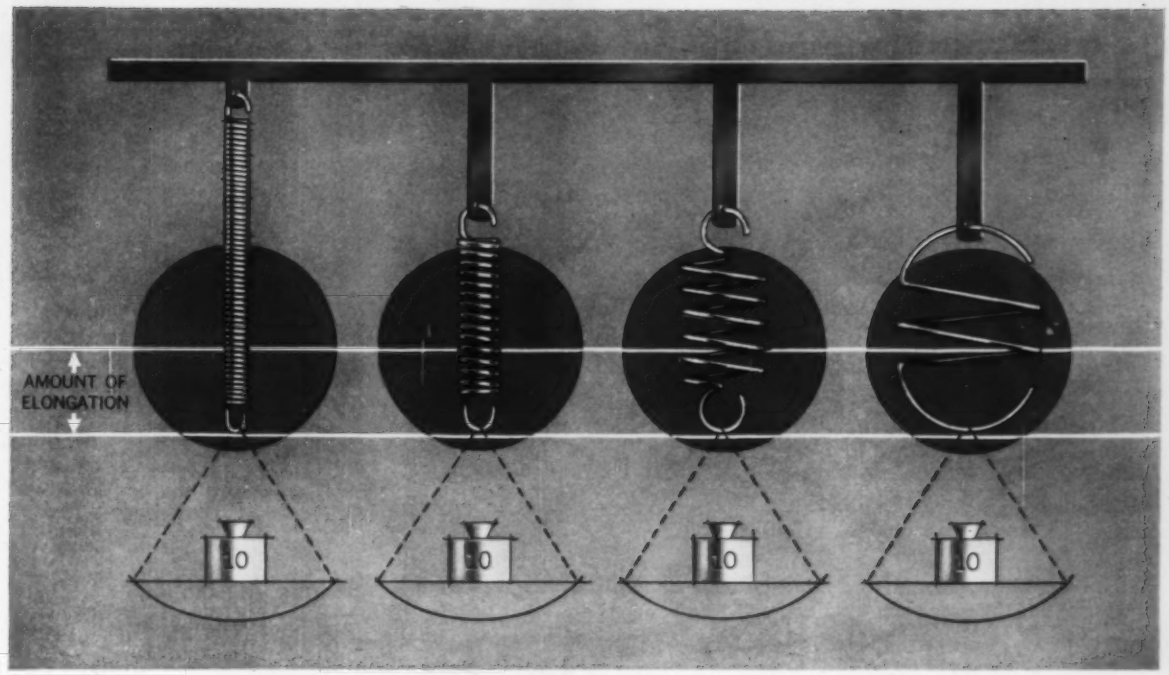
Circle 687 on Page 19

Remote Control

for adjustable-speed drives

New control for Graham infinitely-adjustable-speed drives is designed for panel mounting at remote station. It is for use with drives in sizes from 1/12 to 3 hp, and permits setting of the drive to one part in 4000. Unit provides extreme-

Circle 525 on Page 19



Spring shape and performance— or what does Spring Index mean?

One man distributes his 150 lbs. over a lean 6 ft. frame; another packs the same avoirdupois within a stocky 5 ft. 6 in. height. In a man, this might be expressed as the ratio of height to belt size. In a spring, it's a handy little ratio D/d, that of mean coil diameter to wire diameter. The illustration shows it quickly—same load—10 lbs.; same deflection—0.4 in. But in shape they range from the long thin spring at left with 75.8 coils and a spring index of 3, to the short fat spring at right with few coils and an index of 12. Application of the index ratio is particularly useful where space restrictions exist.

Our long years of specialization have developed many short cuts to spring specification to make your work easier. For general reference purposes write for pamphlet "Spring Design and Selection in Brief."

Associated Spring Corporation

General Offices: Bristol, Connecticut

Wallace Barnes Division, Bristol, Conn. and Syracuse, N. Y.
B-G-R Division, Plymouth and Ann Arbor, Mich.
Gibson Division, Chicago 14, Ill.
Milwaukee Division, Milwaukee, Wis.
Raymond Manufacturing Division, Corry, Penna.
Ohio Division, Dayton, Ohio
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8810

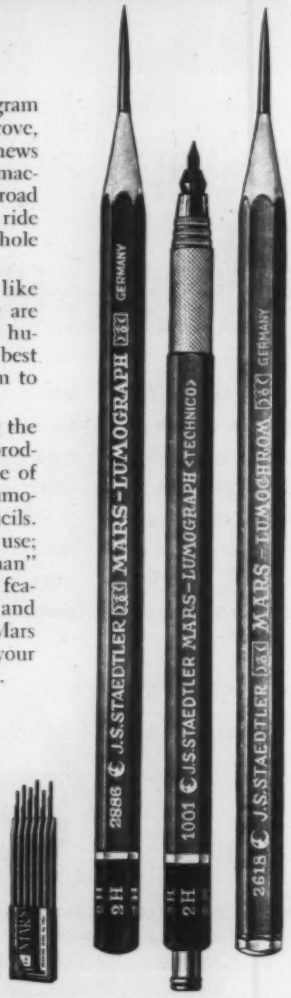
MARS outstanding design **SERIES**

roll your own!

Speeding up our national road-building program is the goal of this design by Russ Henke of Elm Grove, Wisconsin. His behemoth of a machine literally chews up unmapped earth, compacts it with asphalt or macadam, stabilizes it, and lays a ribbon of paved road behind as it rumbles along! Crew and engineers ride in an air-conditioned cabin, and monitor the whole process by control instrumentation.

Tomorrow's *roads* may be squeezed out like toothpaste, but outstanding *ideas* for tomorrow are still produced in the old-fashioned, painstaking, human way. And only professionals know how the best in drafting tools can smooth the way from dream to practical project.

In pencils, of course, that means Mars, long the standard of professionals. Some outstanding new products have recently been added to the famous line of Mars-Technico push-button holders and leads, Lumograph pencils, and Tradition-Aquarell painting pencils. These include the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman" pencil sharpener with the adjustable point-length feature; Mars Lumochrom, the color-drafting pencils and leads that make color-coding possible; the new Mars Non-Print pencils and leads that "drop out" your notes and sketches when drawings are reproduced.



The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom color-drafting pencil, 24 colors.

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

at all good engineering and drawing material suppliers

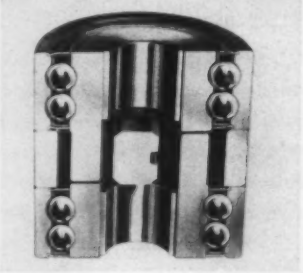
ly accurate remote settings of speeds, from any maximum to zero or into full reverse, as required for machine tool feeds, feeder and pump-rate settings, proportioning controls, and a variety of other applications. **Graham Transmissions Inc.**, Menomonee Falls, Wis.

Circle 688 on Page 19

Bearing Assemblies

for positive control of angular shaft position

Standard bearing assemblies are available for positive control of angular shaft position. They prevent independent movement of a driven shaft except when rotation is produced by a drive shaft. Driven-member lash is less than 2 deg, drive-shaft lash, less than 4.5 deg. Applications include steering mechanisms, aircraft controls, hoists, der-



ricks, punch presses, and ordnance turrets. Torque ratings range from 50 to 2600 lb-in. Bearings are machined to ABEC-1 specifications. **Ann Arbor Bearing & Mfg. Co.**, 815 Wildt St., Ann Arbor, Mich. H

Circle 689 on Page 19

Rotary Actuators

for aircraft applications

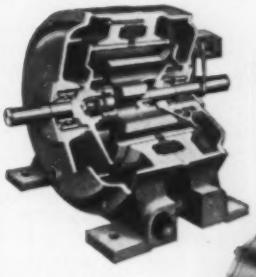
Line of aircraft rotary actuators, designated R-12, combines 12 standard, interchangeable components to provide 40 different, complete units in load ratings to 100 lb-in. and

When You See this Nameplate— You Know Someone Has Solved a Problem!

Your problem may be in the field of speed control, tension control, power transmission, or testing. Dynamatic Eddy-Current Equipment—couplings, brakes, drives, dynamometers — is solving these problems in virtually every industry, in both plant equipment and end products. It can do the same for you.

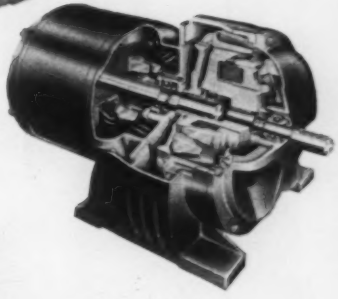
Dynamatic units offer the important advantages of rapid response, wide speed range, quiet operation, low power loss, low maintenance costs, and stepless adjustable speeds from an AC power source.

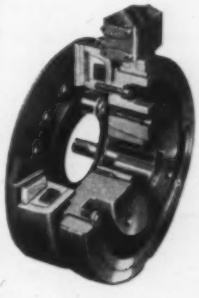
And Eaton Dyna-torQ magnetic-friction industrial clutches and brakes are solving driving and braking problems in all industries where accurate start-and-stop control is required. Check with the Eaton Dynamatic representative or distributor in your locality, or—



DYNAMATIC EDDY-CURRENT COUPLINGS AND BRAKES

DYNAMATIC AJUSTO-SPEDE® AND DYNA-SPEDE® DRIVES





DYNA-TORQ MAGNETIC-FRICTION CLUTCHES, BRAKES, CLUTCH-BRAKES, CLUTCH-COUPLINGS

Send for Illustrated Descriptive Literature
Covering Dynamatic Eddy-Current and Dyna-torQ Equipment

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

versatile

pumping power

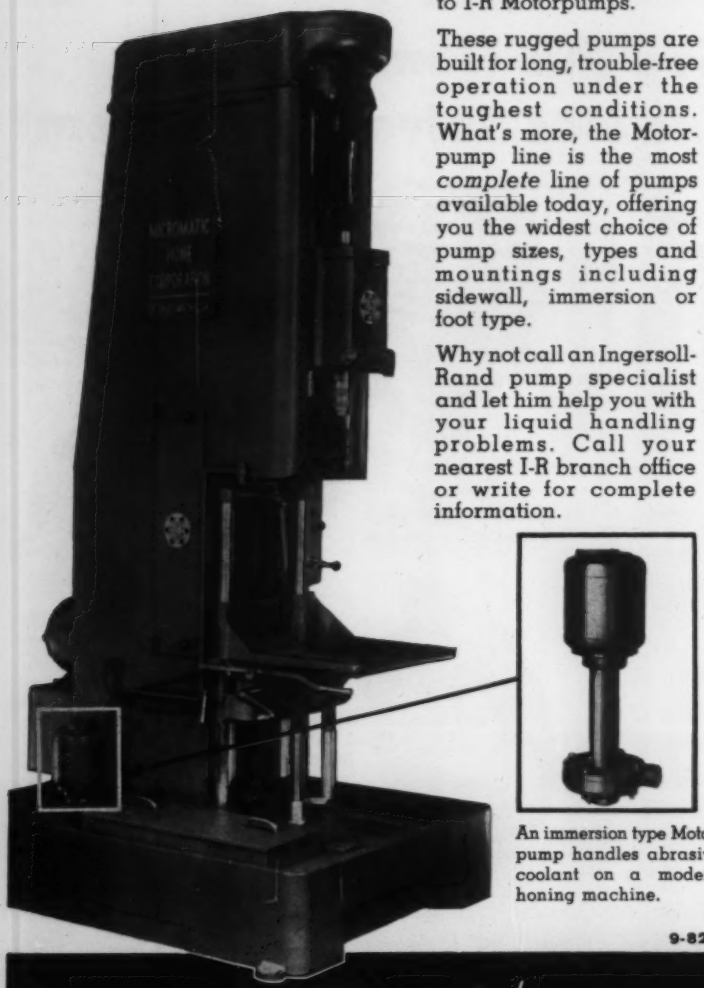
with dependable

MOTOR PUMPS

The efficient handling of coolant, cutting oils and washing liquids in modern production equipment calls for maximum pumping efficiency. And to solve the various problems in all types of equipment, designers today look *first* to I-R Motorpumps.

These rugged pumps are built for long, trouble-free operation under the toughest conditions. What's more, the Motorpump line is the most *complete* line of pumps available today, offering you the widest choice of pump sizes, types and mountings including sidewall, immersion or foot type.

Why not call an Ingersoll-Rand pump specialist and let him help you with your liquid handling problems. Call your nearest I-R branch office or write for complete information.

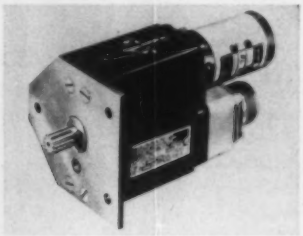


An immersion type Motorpump handles abrasive coolant on a modern honing machine.

9-820

Ingersoll-Rand / 11 Broadway, New York 4, N. Y.

speeds from 0.5 through 50 rpm. Units are available for 115-v, 400-cycle ac operation, or for 26 v dc. Maximum operating load on either current is 100 lb-in., ultimate static load, up to 200 lb-in. Individual components available include low



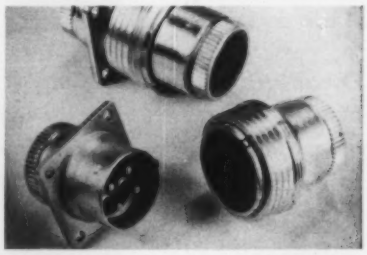
and high-power motors (ac or dc), intermediate, and high gear-reduction sections, accessory drives or transmitters, mounting flanges, and output shafts. **Airborne Accessories Corp.**, 1414 Chestnut Ave., Hillside 5, N. J. D

Circle 690 on Page 19

Electrical Connector

has four No. 12 miniature contacts

Miniature electrical connector has a four-pin arrangement in a 19-pin shell. Four No. 12 contacts are miniaturized, and each carries 40 amp continuously with 50-amp surge.



Designed for use in high-current circuits, connector has a D rating. **Deutsch Co.**, 7000 Avalon Blvd., Los Angeles 3, Calif. L

Circle 691 on Page 19

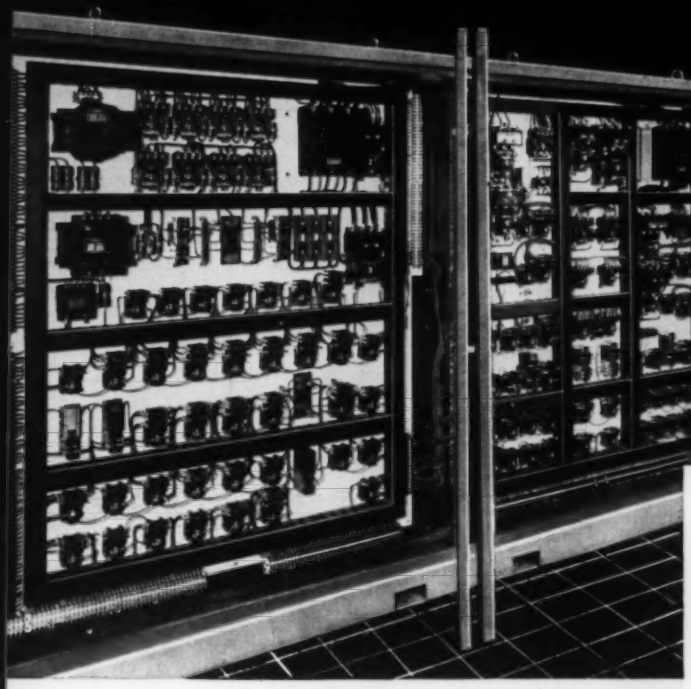
Adjustable-Speed Drive

corrosionproof unit resists acids, gases, dust

Hand-wheel controlled Motodrive provides infinitely adjustable speed over a wide speed range. It resists most acids, gases, and corrosive ducts. Standard subassemblies provide many combinations to fit vari-

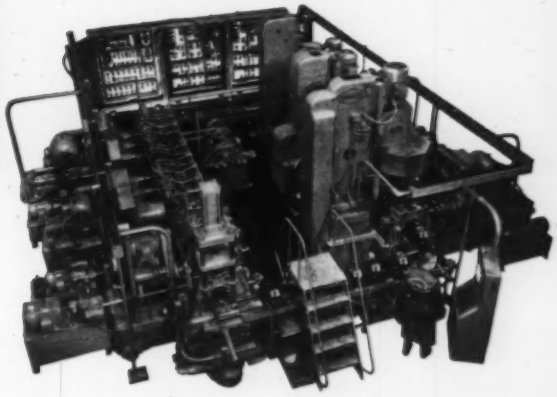
Circle 529 on Page 19

Circle 530 on Page 19→



preferred . . .
because it is
reliable!

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY



This Baker Automatic Transfer Machine is equipped with a special Allen-Bradley control panel, assembled from standard components listed in the latest A-B Handy Catalog.

Twenty-six machining operations are performed automatically on this huge transfer machine. To keep this machine operating continuously—to avoid costly production shutdowns—Baker Brothers, Inc., selected Allen-Bradley quality motor control—the simple control that is good for millions of trouble free operations.

The recognized reliability of Allen-Bradley motor starters and relays is the result of their simple design. Having only *one* moving part, wear and consequent trouble are reduced to the minimum. The double break, silver alloy contacts . . . standard throughout the Allen-Bradley line . . . never need attention. They are always in perfect operating condition.

Simplicity of design and silver alloy contacts are features of all Allen-Bradley control auxiliaries—they are similarly trouble free. Therefore, standardize on the Allen-Bradley line of *quality* motor starters, relays, push buttons, limit switches, and other accessories. You cannot possibly make a mistake!

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

BULLETIN 802T
Oiltight
Limit Switch

Has completely sealed operating head and switch body. This adjustable roller lever type saves installation time.

BULLETIN 700
Solenoid Relay

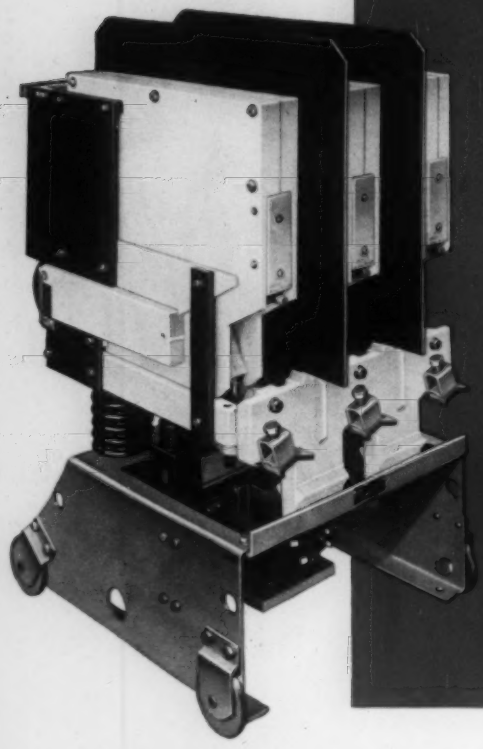
Universal type relay has contacts that can be connected for either "normally open" or "normally closed" operation.

BULLETIN 709
Solenoid
Starter
(Size 1)

Popular across-the-line starter with accurate and reliable overload relays. 8 Sizes to 300 hp, 220 v; 600 hp, 440-550 v.

4-58-R

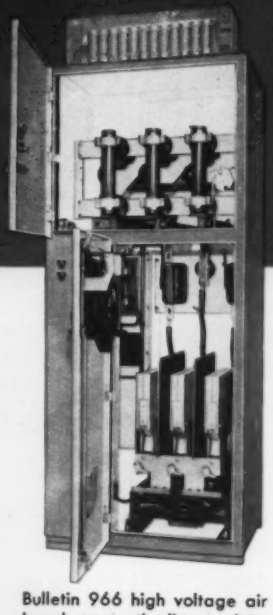
A-B
QUALITY



Air break starters

for high voltage motors

A-B QUALITY



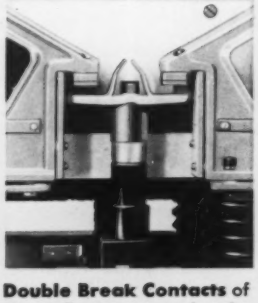
This *new* air break contactor—around which Allen-Bradley has developed a complete line of high voltage starters—is designed to match your *toughest* applications. It features the same solenoid design—with only *one* moving part—that has made Allen-Bradley low voltage starters universally recognized for their tremendous operating life.

These new contactors are available in full voltage and reduced voltage starters—nonreversing or reversing—for squirrel cage, part winding, slip ring, and synchronous motors up to 1500 hp, 2300 volts; 2500 hp, 4600 volts. All starters are equipped with current limiting fuses and have an interrupting capacity of 150,000 kva at 2300 volts and 250,000 kva at 4600 volts.

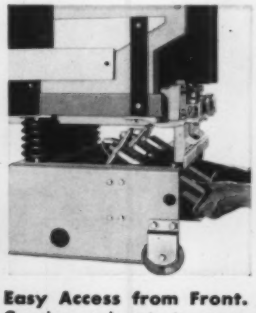
It will pay you to investigate these *quality* starters. Complete information is contained in Publication 6080 . . . please send for your copy, today.

Bulletin 966 high voltage air break, across-the-line synchronous motor starter in NEMA Type 1 enclosure.

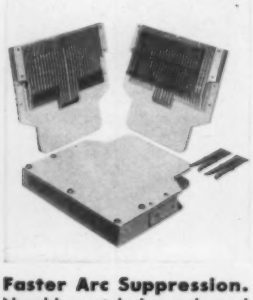
Only One Moving Part. Simple solenoid design eliminates trouble-causing pins, pivots, and flexible jumpers.



Double Break Contacts of silver alloy never need maintenance. Vertical motion assures uniform contact pressures.



Easy Access from Front. Crossbar and contacts removable from front, without special tools, for easy inspection.

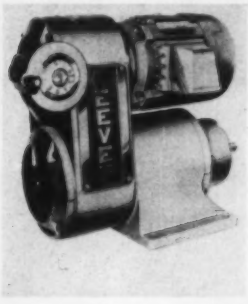


Faster Arc Suppression. New blowout design and novel arc chute. Chutes are molded from an arc resistant material.

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd.
Galt, Ontario

4-58-MR

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY



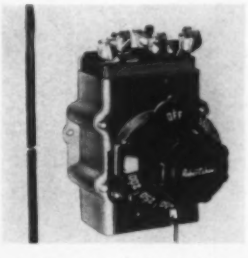
ous space requirements. Lubrication system distributes lubricant into fine grooves in hub bore of sliding disc, thoroughly coating entire sliding contact surface. Gear reducer and conduit box are also corrosionproof. **Reeves Pulley Co., Div., Reliance Electric & Engineering Co.**, Columbus, Ind. J

Circle 692 on Page 19

Thermostat

for temperatures to 700 F

D33 electric thermostat controls three separate heating phases, one of which is on continuously when dial is moved from off position. Two other phases are controlled thermostatically and automatically cycle with changes in temperature. Control is available for industrial and commercial applications in nine different temperature ranges to 700 F. It is constructed of pressed



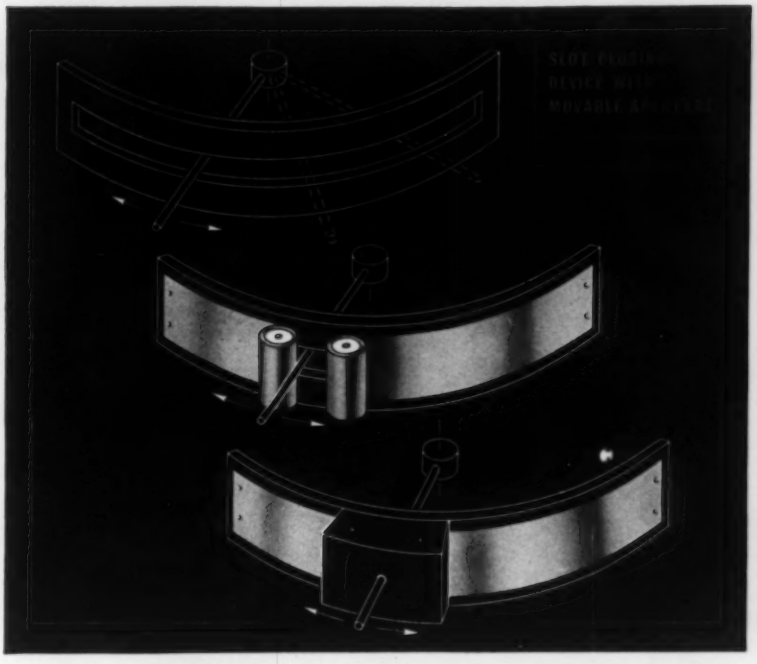
steel, making it suitable for applications where rough usage is encountered. **Thermostat Div., Robertshaw - Fulton Controls Co.**, Youngwood, Pa. G

Circle 693 on Page 19

Mechanical Brake

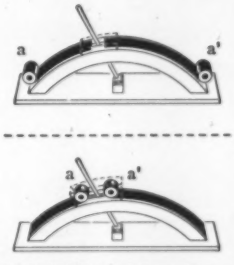
has braking action of 10 lb-in.

Model A-500 mechanical brake gives any rate of index when used in conjunction with a clutch. Unit has



Simplify Slot Closure

WITH NEG'ATOR® SPRINGS



TWO METHODS of mounting NEG'ATORS for slot closure. Above, the free ends of the balanced NEG'ATORS are attached to the traversing unit (the movable aperture) and the NEG'ATOR coils (a and a') are mounted, out of the way, on a stationary section of the equipment. Below, the free ends are fixed and the coils are mounted on the moving member. Where space is available, the mounting below is preferred because of minimized friction.

Paired, equal-force NEG'ATOR Springs, forming flat bands as they uncoil, make an effective cover for slots and provide a movable access through the slot as shown above. This is just another example of how alert engineers have utilized *constant-force* NEG'ATOR Springs to solve unusual design problems.

Slot closure devices incorporating NEG'ATOR Springs are inexpensive, compact and foolproof in operation. Each design utilizes two NEG'ATOR Springs to mask the openings created on either side of the movable aperture. One NEG'ATOR extends as the other re-coils and their equal and unchanging forces counterbalance each other.

Typical application possibilities for NEG'ATOR-equipped slot closure devices include: grinding machine shields, bomber gun turrets, machine tool ways, splash guards, dust enclosures, safety shields, electrical enclosures, and sound baffles—just to mention a few. Can NEG'ATOR Springs solve your particular design problem? Find out more about this versatile component —the first *constant-force* spring—by requesting Bulletin 310N.

HUNTER SPRING COMPANY

3 Spring Avenue, Lansdale, Pennsylvania

Manufacturers of: Precision Springs, NEG'ATOR® & FLEX'ATOR® Constant-Force Springs, Stampings & Assemblies, Retriever Reels, Force Gages, and Wire Fatigue Testers

Circle 531 on Page 19

Quick-Opening Fasteners: Screw Type or 1/4 Turn?

Know the features of each before you specify.

M. R. TUOZZO

The selection of a quick-operating door fastener usually involves a choice between two basic designs; the quick-acting screw fastener and the 1/4 turn fastener. Both are relatively inexpensive. Each has advantages that make it the logical choice for certain applications.

THE SCREW FASTENER is a rugged, square threaded screw assembly engaging in a special heavy stamped nut. The nut is clipped, riveted, or welded to the door frame. A special washer behind the thread captivates the screw in an oversize hole in the door.

Because of its exceptional "float," it is installed without precision measurements and will always line up with ease. Where a variation in material thickness may occur or a gasket must be compressed, the screw fastener is preferred, since a single grip length can be used throughout. Under most conditions it will completely disengage in two to four turns. It offers excellent resistance to vibration and forms a solid joint with no "give."

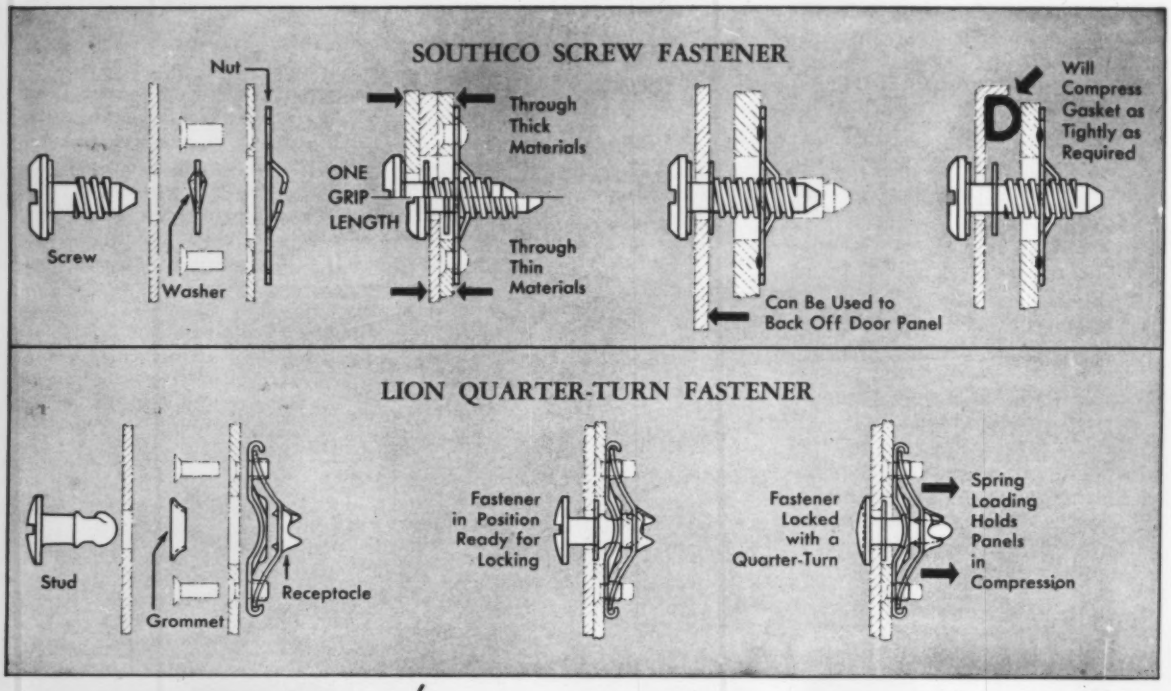
The screw fastener can be backed all the way out of the door frame without moving the door. If required, it can be installed so as to jack the door open as it is unscrewed.

THE QUARTER-TURN FASTENER is usually selected for application on aircraft (under Army-Navy-Air Force specification MIL-F-5591A) where instantaneous removal of fastened parts is required. As the name implies, it is quickly locked or unlocked by a fractional turn.

Its strength characteristics also are very high when the stud is formed from a single piece and no thin springs, wires, or cross pins exist in the assembly. The stud is retained in the door panel by a metal grommet, and engages in a full floating spring-loaded receptacle, riveted or welded to the door frame.

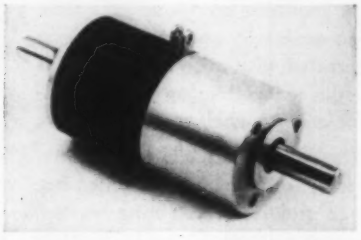
Where the thickness of door and frame are fairly constant through an entire production run, the quarter-turn fastener is a wise choice. Its design affords maximum speed in fastening, and excellent vibration resistance.

COMPARISON OF STANDARD QUICK-OPENING FASTENERS



SOUTHCO FASTENERS
LION
©1956
Southco Div., South Chester Corporation
237 Industrial Highway, Lester, Pa.

braking action of 10 lb-in., control force of 0.06 lb-in., and response time of 0.001 sec. Only required energizing force is that which brings helical-wound spring into contact with brake arbor. Wrapping of spring, which bridges rotating and



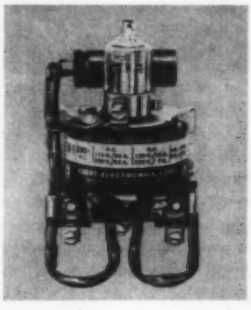
stationary drums, provides braking effect. Standard models offer a choice of normally off or normally on operation and clockwise or counterclockwise rotation. **Digitronics Corp.**, Albertson Ave., Albertson, L. I., N. Y. D

Circle 694 on Page 19

Time-Delay Relay

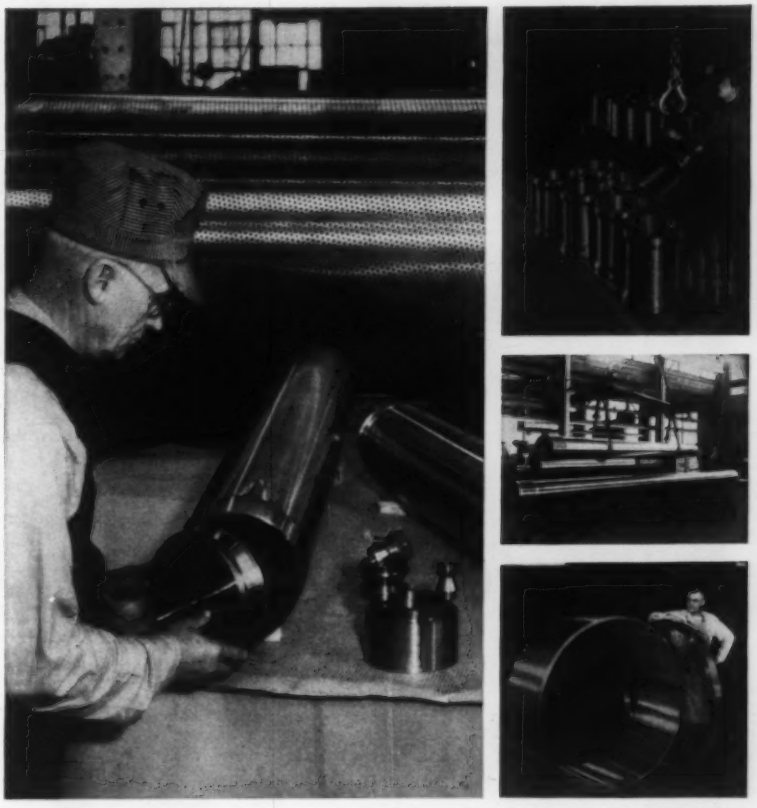
has repeat accuracy of ±5 per cent

Full-power time-delay relay is rated at 20, 35, and 60 amp, or up to 5 hp at 115 v ac. Relay, available in single-pole, single-throw, double-pole, single-throw, and three-pole, single-throw types, offers high load capacities. It has hermetically sealed, positive, mercury-to-mercury snap action. Adjustable delay periods are preset in several ranges from 3 to



120 sec. Timer has repeat accuracy of ±5 per cent. Typical applications include appliances, automation, air conditioning, refrigeration, and delay starting of high-current drain devices. **Ebert Electronics Corp.**, 212-32D Jamaica Ave., Queens Village 28, N. Y. D

Circle 695 on Page 19



Your parts last longer when they're

SHENANGO CENTRIFUGAL CASTINGS

Your machine parts, ferrous or non-ferrous, are subject to stress, strain and friction, day after day, year after year . . . so specify Shenango . . . and see what a difference this makes!

Shenango's centrifugal casting process insures longer life because of finer, more uniform, *pressure-dense* grain to begin with . . . free of inclusions, porosity, blowholes and other weakening defects. Then, far less machining is needed and your part is stronger . . . to last and last *and last!*

Shenango's modern and fully-equipped shops will supply you with ferrous or non-ferrous symmetrical parts in virtually any shape or size . . . rough, semi-machined or precision-finished to your most exacting specifications. For full details, write: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

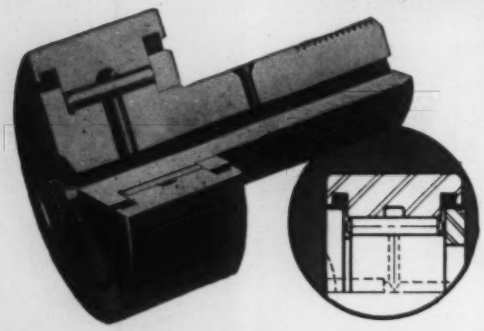
SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

Circle 533 on Page 19

BEARING TIPS by McGill

sealed CAMROL® bearings lock out contamination in critical cam follower applications

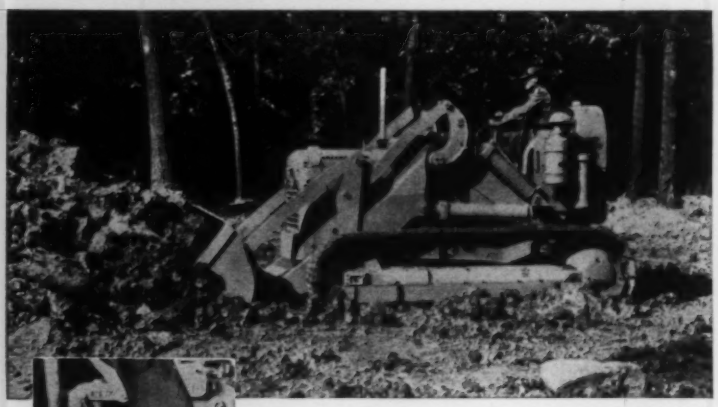


Now Sealed and Prelubricated

The new SCF series of the famous CAMROL cam follower completely seals out dirt, chips, moisture, etc. — an important advantage where the life of an ordinarily open mounted cam follower can be materially increased with adequate protection against contamination. Also the sealed bearing is pre-lubricated with provision made for easy re-lubrication, if desired, through either end of the stud.

Specially treated synthetic seals are contained in the outer race undercuts over the stud flange and roller retaining washer. For added protection, all external surfaces of the bearing are treated to provide a corrosion resistant, black ferrous oxide surface.

These same advantages are available in the SCYR sealed series Cam Yoke Roller (without stud). Specify CAMROL bearings with the built-in seals that preserve cam follower dependability in critical cam action, support or track roller application.



Built-in seals protect and preserve CAMROL® bearings from contamination in CATERPILLAR-built TRAXCAVATORS®

McGill SCF series sealed CAMROL bearings provide the cam action that positions the bucket of the No. 977 Traxcavator unit at the selected digging angle. Mounted on bell crank arms that are actuated by contact with a cam shoe on a hydraulic cylinder linkage, these bearings are operating in the open and exposed constantly to dust, dirt and moisture. External surfaces have a black ferrous-oxide finish to prevent corrosion. These sealed McGill cam followers eliminate the need for relubrication and maintenance after installation. Caterpillar uses other McGill bearings including twelve CYR series cam yoke roller bearings in the flywheel clutch.

378 sealed CAMROL® bearings guide engine blocks in INGERSOLL automatic milling machine

The sealed CAMROL bearings used in this machine, guide cylinder blocks during transfer through various milling, boring and drilling operations. The bearings, used in place of guide bars, eliminate surface scratching of the 200 to 300 pound blocks which are transferred at speeds up to 400 feet per minute. Blocks are processed at the rate of 95 per hour. Ingersoll reports freer movement, accuracy of positioning and materially longer bearing life due to the new design that seals metal chips out of the bearings.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Precision Needle Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

ENGINEERING DEPARTMENT

EQUIPMENT

Pen Kit

for use with templates and lettering guides

Omnigraphos is a specialized pen kit for use with schematic drawing templates and lettering guides. It contains a barrel fountain pen with 12 tubular nibs for drawing or matching ink lines from 0.3 to 2.5 mm wide, regardless of curve of tem-

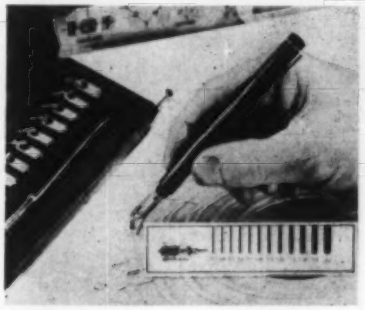


plate. Offset angle of interchangeable nibs permits them to hug guide-slot walls tightly. Kit shown includes a complete range of nibs, holder, and self-regulating ink feed. **Laramie Chemical Corp.**, 290 Main St., Stamford, Conn. B

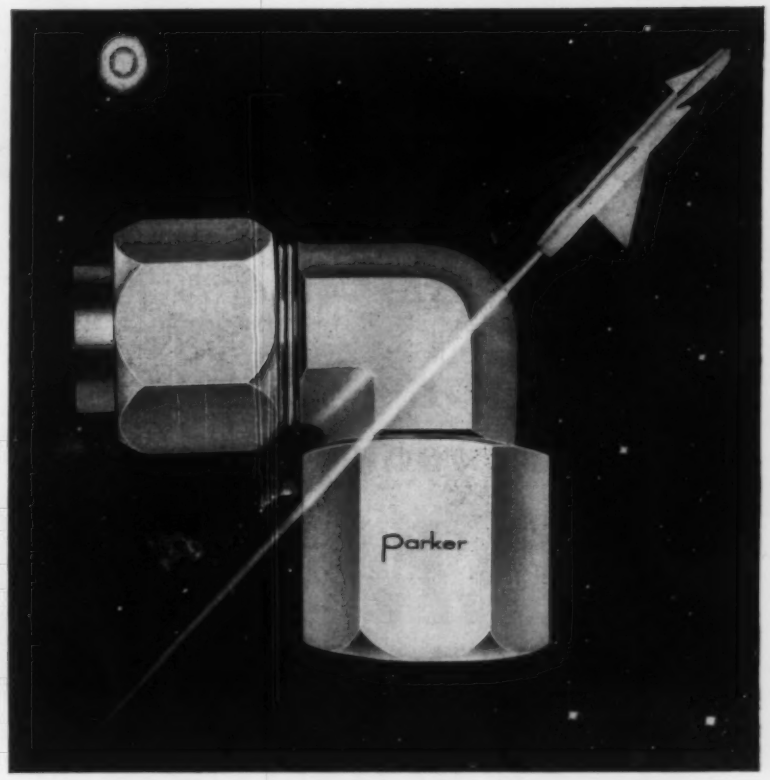
Circle 696 on Page 19

Oscilloscope

four-channel unit has plug-in accessory circuits

Model K-470 four-channel, wideband oscilloscope handles all oscilloscope applications from dc to 5 mc, including medical, biophysical, geophysical, and direct strain-gage recording. Unit incorporates plug-in preamplifiers, sweep generators, and marker-calibrator. Choice of five preamplifiers provides different sensitivity and frequency characteristics to meet specific requirements. Two identical sweep generators permit viewing all four channels on common or separate time bases. If separate sweeps are not required,

(*Continued on Page 216*)



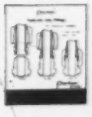
Parker Triple-lok fittings stand up under severest temperatures and stresses

Exhaustive tests by Parker and by missile builders prove that Triple-lok tube fittings stand up under the severest punishment of rocket stresses and strains, high pressures and temperatures . . . give you leakproof, dependable, *safe* connections.

Used on missiles and launching pads, Triple-lok fittings simplify construction, provide trouble-free connections, last longer. No matter how close the quarters, or how intricate the system, Triple-lok fittings are fast, easy to install.

Will even hold helium. Parker Triple-lok fittings can be furnished with specially treated flare nose surface that will trap even elusive helium, which no ordinary metal-to-metal seal can do.

The industrial standard. Triple-lok fittings come in a wide range of sizes and shapes (including *straight* threaded and *female* pipe threaded bodies). Available in type 316 stainless steel; in other alloys on special order. Warehouse stocks in all industrial centers. Ask your Parker Distributor for Triple-lok Catalog No. 4310, or write to —



PARKER FITTINGS AND HOSE DIVISION

Section 430-V, Parker-Hannifin Corporation, 17325 Euclid Ave., Cleveland 12, Ohio

Parker Hannifin
creative leader in fluid systems

Circle 535 on Page 19

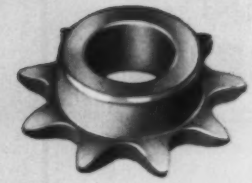
WHATEVER THE APPLICATION...

you can improve your product with

GRAMIX®

(PRODUCT OF POWDER METALLURGY)

PRECISION FINISHED PARTS



Hardened steel drive sprocket for lawnmower

Aircraft control cable guide

Self-aligning guide bearing for industrial blower shaft

GRAMIX precision finished parts are improving products in virtually every branch of industry. A pump manufacturer, for instance, may specify a gasoline pump rotor made of GRAMIX and gain a number of advantages.

To begin with, the alloys are carefully blended to meet his individual requirements. The GRAMIX parts are then die-pressed to exact shape, sintered under rigid control and finished to tolerances as close as .0005". (This process, of course, costs far less than machining, forging or casting.) The manufacturer can expect the GRAMIX gasoline pump rotor to do a better job because *all* GRAMIX parts are precision engineered and precision controlled from alloying to finishing.

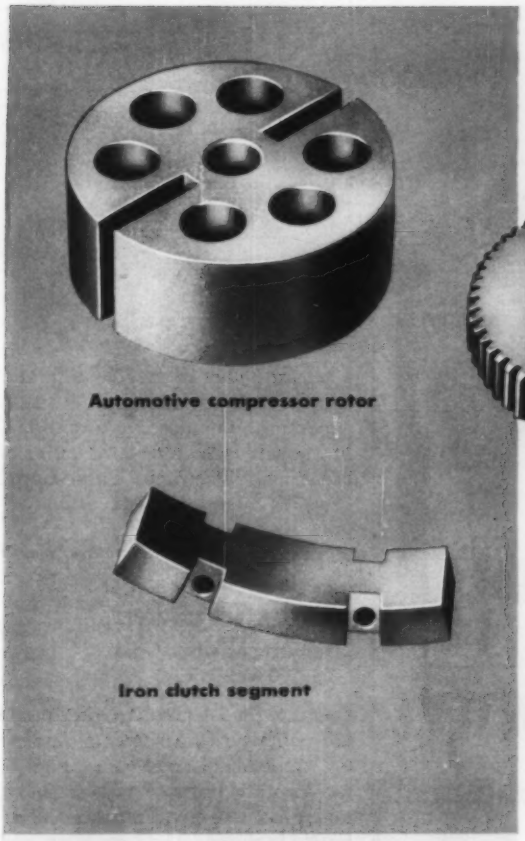
No matter what the application may be, GRAMIX parts fit specifications exactly. Parts may be impregnated with oil . . . to insure a longer life and a quieter operation: if specified, the GRAMIX parts may be coined and work hardened, even prepared for plating.

The rotor is only one of thousands of applications in which GRAMIX precision finished parts have proved to be ideal. Just a few of them are shown here, so consider the components of your products . . . there may be several that could be improved . . . with GRAMIX! Products of powder metallurgy you can rely on.

PM MEMBER

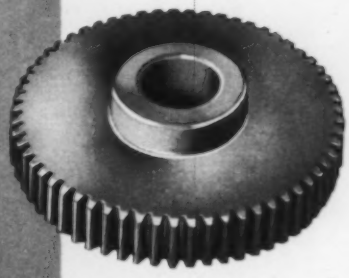
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



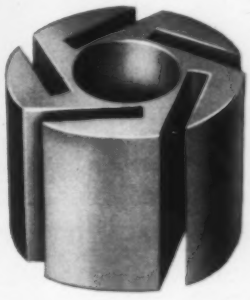
Automotive compressor rotor

Iron clutch segment



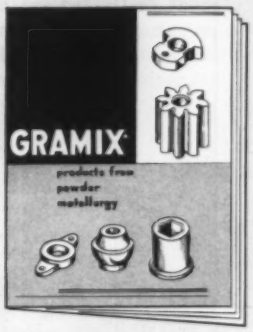
Infiltrated iron gear for lawnmower

Iron switch control

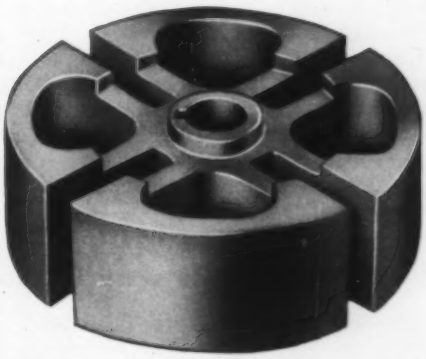


Rotor for gasoline pump

Packing gland follower used in hydraulic system



Write today for factual Engineering Bulletin No. 21 . . . we'll send your copy right along.



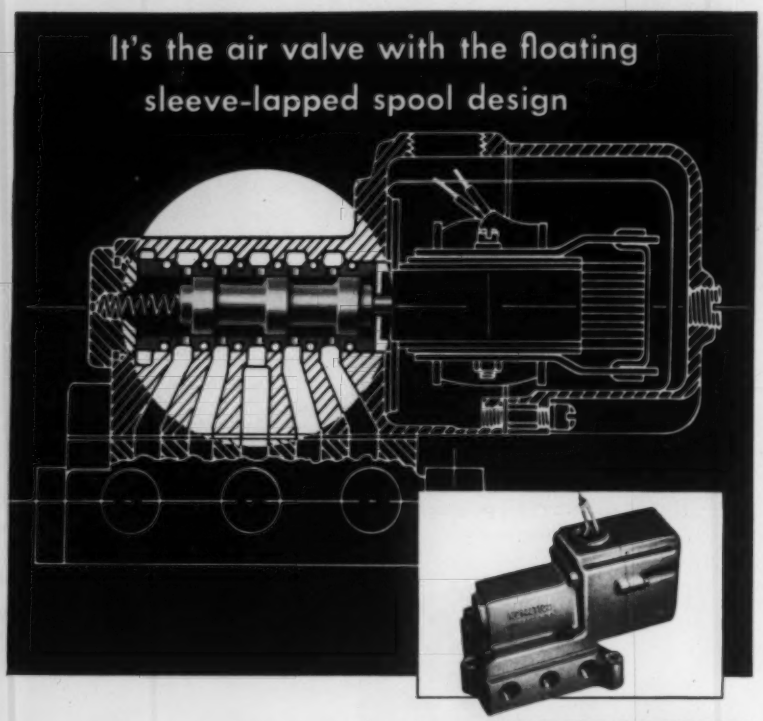
Bronze rotor in high speed fueling unit

X-253-1

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 536 on Page 19



Starts every time—INSTANTLY!

no sticking, lubrication or dirt problems

Familiar with those Monday morning epidemics of sticking valves? Never happens with Numatics air valves . . . not even after *months* of idleness. Because the patented floating sleeve-lapped spool design eliminates the major cause of sticking . . . moving elastic seals. Sealing is accomplished, instead, by the precision finish and close tolerance between spool and sleeve.

And no-stick, no-leak sealing is just one advantage of Numatics valves. Lubrication is no problem, for a Numatics valve is impervious to oil additives. They'll operate on *any* standard lubricant . . . or, they'll run dry if the application requires it. Dirt is no problem, either, because the file hard, razor sharp spool lands and orifice edges chop dirt particles to a fineness that permits passage through the valve without the slightest damage. What's it all add up to? . . . a valve that's more *reliable* and trouble-free, a valve that will last longer than any air valve now available. For complete details send for your copy of catalog #158.

NUMATICS leads the way in manifolds too

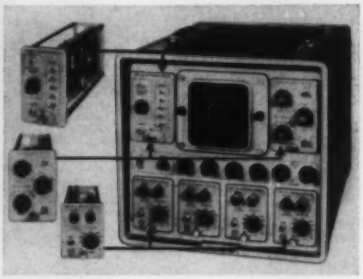
For greater efficiency, lower cost, streamline your valve installations with Numatics multiple mount manifolds. Three types available . . . individual or common exhaust and conduit . . . in 2 to 6 stations, 4 pipe sizes. SA Valves mount interchangeably, too!

NUMATICS, Inc. HIGHLAND, MICHIGAN

SALES REPRESENTATIVES FROM COAST TO COAST

Circle 537 on Page 19

(Continued from Page 213)



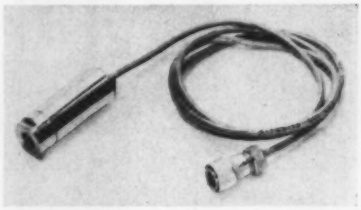
a separate plug-in marker-calibrator can be substituted for one sweep generator. Oscilloscope uses a 5½-in., square-face, four-gun, cathode-ray tube. **Electronic Tube Corp.**, 1200 E. Mermaid Lane, Philadelphia 18, Pa. E

Circle 697 on Page 19

Pressure Transducers

for temperatures from − 100 to 300 F

Glennite PSG-1 pressure transducers are cavity-type instruments utilizing the unbonded strain-wire principle for accurate pressure measurements under extreme environmental conditions. Including absolute, gage, and differential-pressure types, they are designed primarily for the measurement of fluctuating or steady-state pressures in liquids or gases. They are insensitive to vibration and acceleration and have minimum ther-



mal shift due to temperature change. Gages are available in seven standard ranges from 25 to 300 psi, and are suitable for environmental temperatures from − 100 to 300 F. **Gulton Industries Inc.**, 212 Durham Ave., Metuchen, N. J. D

Circle 698 on Page 19

Viewer-Enlarger-Processor

produces 18 x 24-in. prints from unitized microfilm

Micromatic is a fully automatic viewer-enlarger-processor, controlled by a single pushbutton, which au-

Flexloc thin nuts help you build lighter, more compact bolted assemblies

Self-locking nuts save weight, space, production time... help increase product reliability

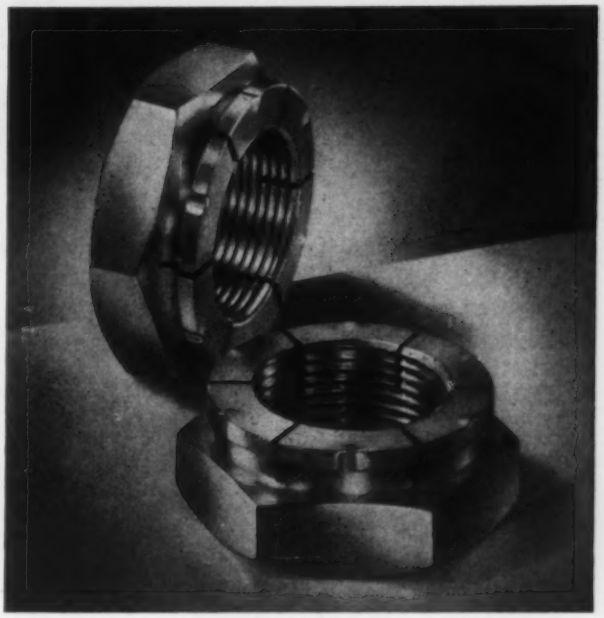
Self-locking FLEXLOC thin nuts are 30% lower—and correspondingly lighter—than regular height locknuts of the same nominal diameter. They not only fit into spaces where regular height locknuts will not go, but also provide full locking action with shorter bolts, thus saving still more weight. With FLEXLOC thin nuts, you can design smaller, lighter bolted assemblies without sacrificing strength or reliability.

FLEXLOC thin nuts also help save production time. Because length of engagement of mating threads is shorter, fewer revolutions of hand wrenches or power nut runners are needed to seat FLEXLOC thin nuts.

FLEXLOC nuts are of 1-piece, all-metal design in which every thread, including those in the locking section, carries its full share of the tensile load. There are no nonmetallic inserts to waste head space or weaken the structure of the nut. And no auxiliary locking elements are required... nothing to put together, come apart or get lost. You can use a FLEXLOC as a locknut or a stopnut. It locks, seated or not, wherever wrenching stops. It will not vibrate loose, yet can be removed easily and reused many times.

See your authorized SPS distributor for more information. He carries FLEXLOC self-locking nuts—thin height and regular—in a full range of standard sizes and materials. Or write Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

See us at the ASTE Show, May 1 to 8, Booth 322



SPECIFICATIONS
FLEXLOC THIN NUTS

NATIONAL COARSE THREAD—U.S.S

SIZE	A INCHES	H INCHES	WIDTH ACROSS CORNERS	WEIGHT PER 1000 NUTS
6-32	.312	.125	.361	1.8
8-32	.344	.172	.397	2.8
10-24	.375	.172	.433	3.3
¼-20	.438	.203	.505	5.4
5/16-18	.563	.250	.649	11.6
3/8-16	.625	.265	.722	14.9
7/16-14	.750	.312	.866	24.9
½-13	.813	.312	.938	28.4
9/16-12	.875	.359	1.010	36.1
5/8-11	1.000	.391	1.155	54.1
¾-10	1.125	.406	1.299	69.2
⅞-9	1.312	.469	1.516	107.5
1-8	1.500	.563	1.732	171.6
NATIONAL FINE THREAD—S.A.E.				
6-40	.312	.125	.361	1.8
8-36	.344	.172	.397	2.8
10-32	.375	.172	.433	3.3
¼-28	.438	.203	.505	5.4
5/16-24	.500	.250	.577	8.7
3/8-24	.563	.266	.649	11.5
7/16-20	.625	.312	.722	14.9
½-20	.750	.312	.866	21.7
9/16-18	.875	.359	1.010	36.2
5/8-18	.938	.391	1.082	42.4
¾-16	1.063	.406	1.227	54.5
⅞-14	1.250	.469	1.443	84.6
1-14	1.438	.563	1.660	136.3
1 1/16-12*	1.625	.625	1.876	193.5
1 ¼-12*	1.813	.750	2.093	296.0
1 3/16-12*	2.000	.812	2.309	389.0
1 ½-12*	2.187	.875	2.526	498.0

*Steel only (plain or cadmium plated) in stock sizes.

Standard FLEXLOC thin nuts are available in plain or cadmium plated alloy steel for temperatures to 550°F; in plain or silver plated corrosion resisting steel for temperatures to 750°F; and in brass and aluminum for temperatures to 250°F.

hiRf — *High Reliability factor*

At SPS we apply a dynamic standard of quality—continually refined—so that our fasteners will always have the high reliability factor required by today's faster speeds, higher temperatures, and greater dynamic stresses. By using SPS fasteners in your assemblies, you help increase overall reliability—the certainty of predictable performance under actual service conditions.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "Concerning High Reliability."

We also manufacture precision titanium fasteners / write for free booklet

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Solve Your
HOT PROBLEMS
with
VULCAN VERSATILITY

IN CARTRIDGE HEATERS

Vulcan Electric Cartridge Heaters are especially designed for insertion into machine parts, dies, platens, molds, presses, die blocks of embossing machines, packaging machines, etc.

You have a wide choice of standard sizes — from 1" to 25" (or longer); diameter — ¼" to 1¹¾₆₄" (or greater); wattage — 10 to 3200 (or higher); voltage — standard 120 or 240, special 6 volts up; sheath — brass, steel, nickel or high temperature alloys; standard or special lead wires or terminals.

When your hot problems call for unusual specifications, you get a speedy solution through *Vulcan Versatility* — in design, engineering and production. Standard or special, Vulcan is ready to supply your complete needs in low cost, efficient heating units. Send coupon for Catalog and prices.

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Cartridge • Strip • Tubular • Immersion Electric Heaters • Soldering and Branding Irons Solder and Glue Pots

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Danvers 6, Mass.

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☐ Cartridge ☐ Tubular
☐ Strip ☐ Immersion
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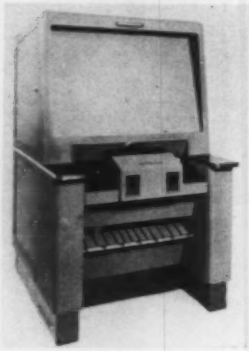
NAME & TITLE.....
COMPANY.....
STREET & NO.....
CITY & STATE.....

Circle 539 on Page 19

tomatically delivers stabilized, high-quality prints in less than a minute. Unit selectively reproduces an 18 x 24-in. paper print from microfilm image on Actifilm, Ozacard, or aperture card up to 3¼ x 7⅜ in. Finished print can be on either standard weight or trans-



lucent paper. Magnification is 20X for viewing and 15X for enlarging; viewing screen is 24 x 36 in. Developer section is removable for easy maintenance. Unit operates on 110 v ac, 60 cycles. **Ozalid Div., General Aniline & Film Corp.**, 11 Corliss Lane, Johnson City, N. Y. D

Circle 699 on Page 19

Molded Nylon Parts

provide cross-section of typical applications

Assortment of molded nylon parts is available as a free sample kit to provide a typical cross-section of nylon applications. Parts can be used in experimental work and serve as models of design for mass production by the injection-molding process. **Nylomatic Corp.**, 107 W. Trenton Ave., Morrisville, Pa. E

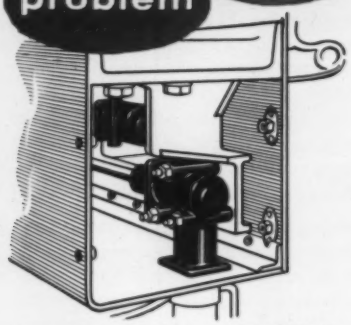
Circle 700 on Page 19

Voltage-Digital Converter

completes 3700 conversions in 1 sec

Model B617 Datrac is a high-speed electronic voltage-to-digital converter which converts input voltages to four binary-coded decimal digits, with accuracy of ±0.05 per cent of reading ±one-half the least significant binary digit. More than 3700 such conversions can be completed in 1 sec. Standard full-scale

ANGLgear solves space and weight problem



Drawing based on photo shows Model R-320 ANGLgears used on Goodyear missile-handling equipment. Compact, high-capacity ANGLgears solved problem of 90° drive in restricted space.

In designing its missile-handling equipment, Goodyear Aircraft Corp. required several 90° power takeoffs for the Nose and Booster handling pack. Combing the field of available right-angle gears, Goodyear engineers determined that ANGLgear was best capable of performing the necessary functions and meeting space and weight requirements.

Perhaps you have a similar design problem involving right-angle power transmission in a restricted space. If so, ANGLgear offers you high capacity, compactness and light weight, plus the flexibility of 4-way mounting. Furthermore, ANGLgear is completely enclosed, permanently lubricated; requires virtually no maintenance.

ANGLgears are available from stock in ⅓ to 5 hp ratings, with 2 or 3-way shafting, and 1:1 or 2:1 gearing. See our literature in Sweet's Product Design File or contact your local distributor.

AIRBORNE®
AIRBORNE ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Circle 540 on Page 19

Tubexperience in action

Superior weighs a wall to "zero in" on your tubing tolerance

Weight control gives precise check of tubing dimensions to help your product performance

*These delicately balanced scales weigh a length of tubing accurately to within 1/1000 lb. The relationship of weight to length and to OD tells us how closely the tubing wall or ID conforms to specifications. This fast, precise method of checking average wall or ID enables us to provide you with a tubing order whose overall uniformity is unusually high. In certain applications, tubing produced by this weight control method can materially improve performance for you. It results in minimizing variations in your product caused by tubing whose average wall or ID varies too widely from the required design mean.

This is but one of many modern tools and techniques that help improve the already high quality of Superior small tubing.

Our premium quality small tubing is offered in a range of analyses (over 120) unsurpassed in the industry. Included are stainless, carbon and alloy steels, nickel and nickel alloys, beryllium-copper, titanium and zirconium—and 16 different Super Alloys. Our range of sizes and shapes is equally extensive.

Special services include statistical quality control, pilot and test lot sampling and melting, dye penetrant inspection, ultrasonic and hot tensile testing, eddy current and X-ray inspection, specification services—and field specialists who will call on you at your request.

For handy reference in your files, get a copy of Bulletin 40, "Selection and Application Guide for Superior Tubing." Write Superior Tube Company, 2010 Germantown Ave., Norristown, Pa.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company • 5710 Smithway St., Los Angeles 22, Calif. • RAymond 3-1331

NEW Complete Line of Hydraulic

POWER STEERING

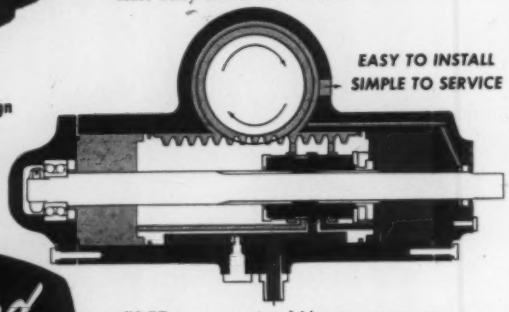
FOR EVERY PIECE OF STEERABLE EQUIPMENT BUILT

Compact, unified design permits installation of Sheppard Power Steering in most equipment without extensive engineering changes. Sheppard has 8 standard models . . . plus many special units . . . making it easy for you to offer full-time power steering on your equipment with the least delay and at lowest cost.

HIGH QUALITY AT LOW COST

Result of Simple, Rugged Design

Cutaway illustrates oil flow pattern, simplicity of design and minimum of moving parts in Sheppard Integral Power Steering Units.



EASY TO INSTALL
SIMPLE TO SERVICE

Sheppard POWER Steering

FREE power steering folder yours on request . . . Write today! Sheppard's Engineering Staff is at your service to help you select the Power Steering best suited to your equipment.

R. H. SHEPPARD COMPANY, INC. • HANOVER, PA.

BUILDERS OF DIESEL ENGINES
AND POWER STEERING UNITS FOR INDUSTRY

Circle 542 on Page 19

rotating shaft
seals
by Cartriseal
for all types
of products
Multi-Purpose Single Face "O" Ring.
Floating Labyrinth Seal for temperatures as high as 1400°F. and shaft speeds up to 150,000 rpm.
Metal Bellows Seals to fit any shaft size. Also: Cartridge Seals and Grommet Seals.

CUSTOM-ENGINEERED
to meet your specific requirements

Cartriseal solves seal problems of high rpm . . . temperature extremes . . . corrosion. Send specifications. No obligation.

CARTRISEAL

Cartriseal Corporation

5818 W. FOURTH AVENUE LINCOLNWOOD 46, ILLINOIS

Circle 543 on Page 19

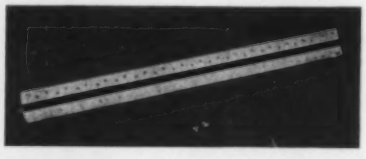
input ranges of ±10, 100, and 1000 are provided, with range switching accomplished by application of an external trigger pulse. High conversion rates are obtained if electronic input range switching is not required. Auxiliary equipment is available for handling multichannel analog inputs to the converter. Unit can be used for data logging, data processing, process control, and computer-linkage applications. **Epsco Inc.**, 588 Commonwealth Ave., Boston 15, Mass. B

Circle 701 on Page 19

Triangular Scales

have white plastic faces

Boxwood 12-in. professional triangular scales are available in open divided graduated models, fully divided chain scales, and combination open and fully divided units. Faces are white plastic for durability and lightness. Scales are engine-divided for sharpness of graduation, and



have colored furrows for quick choice of desired scale. **Alvin & Co. Inc.**, 853 Palisado Ave., Windsor, Conn. B

Circle 702 on Page 19

Vibration Pickups

for vertical, horizontal, or omnidirectional mounting

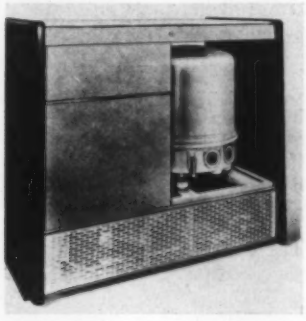
Three new vibration pickups, operable over temperature range of − 65 to 500 F, are for in-flight monitoring of jet engines and other constantly vibrating equipment such as motors and generators. The small units, designated Types 4-121,

4-122, and 4-123 (shown), perform in oily or corrosive atmospheres; sand, dust, or fungus cannot penetrate hermetically sealed interiors. Internal construction and damping differ slightly in three models to allow horizontal mounting of 4-121, vertical mounting of 4-122, and omnidirectional mounting of 4-123. Pickups do not affect vibration characteristics of equipment under test. They monitor vibrations to 2000 cps. **Consolidated Electrodynamics Corp.**, 300 N. Sierra Madre Villa, Pasadena, Calif. L

Circle 703 on Page 19

Bulk-Storage Device

for data-processing systems



HD-File Drum is a random-access bulk-storage device with wide application to data-processing systems. It stores 1040 bits per in., has 320 tracks, and stores a total of 15 million bits. Average access time to stored data is 180 milliseconds. Unit consists of a file drum, drive and lubrication systems, 3 x 10 x 10 track-selection mercury-relay matrix, linear read-out preamplifier, and final-writing amplifier. File drum, 15 in. in diam and 14 in. high, is completely enclosed and sealed. It is dynamically balanced at 1200 rpm. **Computer Products Div., Laboratory for Electronics Inc.**, 141 Malden St., Boston 18, Mass. B

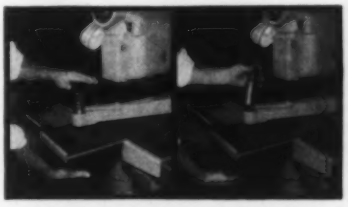
Circle 704 on Page 19

THE STRIPPIT FABRICATOR — a single compact multi-purpose Punch Press with quick-change tool holder, quick-set gauging and stops.

Short run? Complicated pattern? If it's sheet metal up to ¼" mild steel, if it's punching, notching or nibbling, it's profitable on a Strippit Fabricator!

Set up in minutes! Punches and dies are changed in 30 seconds or less, and Strippit guided punches need no aligning or adjusting. Back stop with precision gauge is instantly set by a locking knob. Self-tripping finger stops on gauge bars provide multiple stopping as the work is moved rapidly under the punch. A switch gives you single punching or 165-stroke-a-minute nibbling, and all tools are within quick reach in attached "file drawers" or shelves. The Fabricator is more than a one-machine shop — it's a whole system of quick-change, high-profit fabrication used by thousands of shops.

What's more, you can add the Strippit Positive Duplicator for high-speed punching in medium runs — plus the Dupl-O-Scope to punch Duplicator templates right from the drawing, in a few minutes. Write today for details and demonstration at your plant by the Strippit mobile unit. Warehouse stocks in Chicago and Los Angeles.



TOOL HOLDER is pulled out, for instant removal of die and punch assembly, ready for the next interchangeable tool. 1¼" diameter capacity holder shown, 3½" diameter holder also available.

UNIT OF HOUDAILLE INDUSTRIES, INC.

WALES STRIPPIT COMPANY

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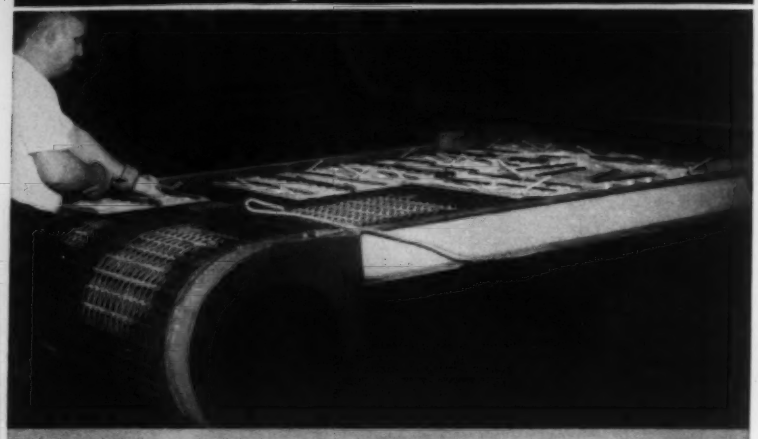
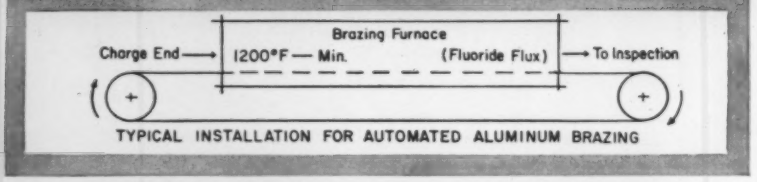
Circle 544 on Page 19

Cambridge WOVEN WIRE BELTS





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Here's a belt that not only shrugs off hot atmospheres and corrosive fluxes, but helps process metal parts more uniformly—and in less time. Moving continuously through the furnace, the Cambridge Belt allows heat to circulate freely through its open mesh and around the product for thorough treatment.

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OPEN MESH PROVIDES FREE AIR, LIQUID CIRCULATION—gives more uniform processing of product; grit, sand, quench solutions drain through belt immediately.

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Whether you design machinery for your own use or for resale, your Cambridge Field Engineer can explain how the many advantages of Cambridge Belts make continuous processing practical and economical. And, he'll recommend the belt size, mesh or weave—in the metal or alloy—best suited to your needs. He's listed in the classified phone book under "BELTING, MECHANICAL." Or, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

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Recent Books

Automation in Business and Industry. *Edited by Eugene M. Grabbe, senior staff consultant on automation, The Ramo-Wooldridge Corp., 611 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$10.00 postpaid.*

This book contains information on the fundamentals of automation, new developments in automation techniques, and descriptions of automation system applications.

The material shows how the fields of feedback-control theory, instrumentation, analog and digital computation, and data processing are becoming integrated as automation is applied. Emphasis is placed on those applications of control systems which can perform both complex control functions and electronic data processing.

Engineering Formulas and Tables. *396 pages, 3¾ by 6¾ in., loose-leaf binder; published by and available from Lefax Publishers, Ninth & Samsom Sts., Philadelphia 7, Pa.; $4.75 per copy.*

This reference manual contains basic formulas, design data, and tables for three branches of engineering—civil, electrical, and mechanical. Sections include mathematics, measures, materials, mechanics, electricity and magnetism, hydraulics, structural data, pipe and fittings, steam tables, and mathematical tables.

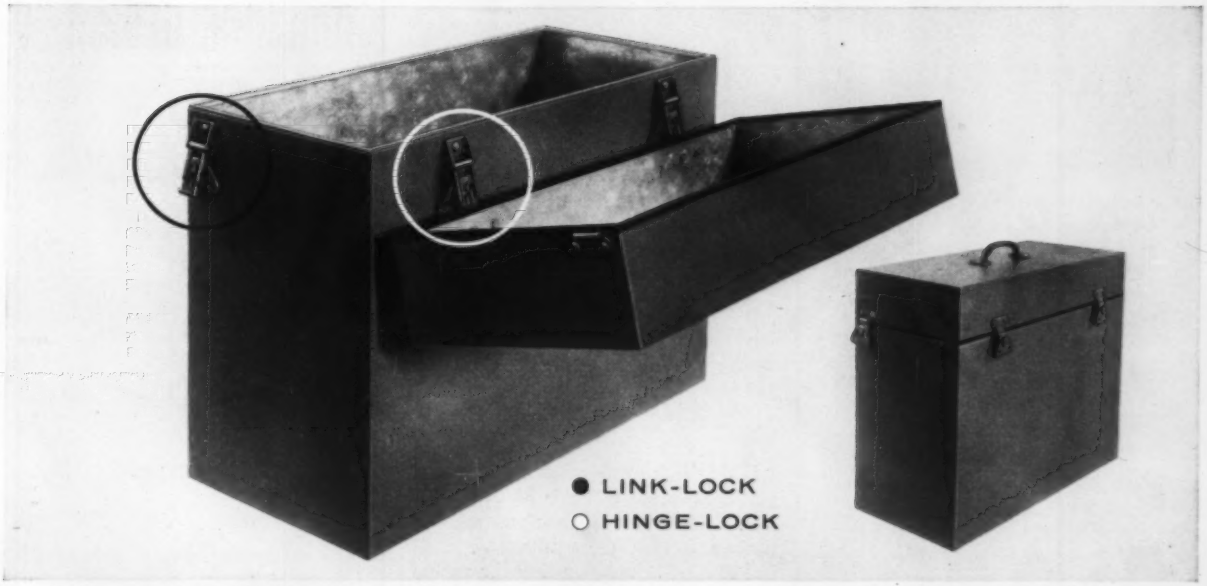
Association Publications

Physical Metallurgy of Aluminum Alloys. *247 pages, 6 by 9 in., clothbound; published by and available from American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; $5.00 per copy.*

This book contains reprints of five lectures on the subject delivered during the 28th National Metal Congress and Exposition. The major

Now

An all-around pressure-tight seal for hinged-cover transit cases with LINK-LOCK and HINGE-LOCK



No. 3 LINK-LOCK

No. 3 HINGE-LOCK

Two HINGE-LOCK and two LINK-LOCK Fasteners provide all-around sealing pressure on this container manufactured for the U.S. Navy by the Bonded Structures Division, Swedlow Plastics Company.

The new Simmons HINGE-LOCK, used in combination with LINK-LOCK, provides an even, pressure-tight seal on equipment containers and transit cases with hinged covers. A half-turn applies pressure to both types of fasteners. When pressure is released HINGE-LOCK becomes a free-operating hinge, and LINK-LOCK disengages to permit opening.

Originally developed by Simmons Fastener Corp. for the Engineering Department of Swedlow Plastics Company, Bonded Structures Division, HINGE-LOCK is similar in principle and appearance to LINK-LOCK. Both are available in light and medium duty sizes as matched hardware. LINK-LOCK is also available in a higher-capacity, heavy-duty size.

SEND TODAY for complete data, including dimensions, capacities. Engineering service is available... Outline your requirements. Samples on request.

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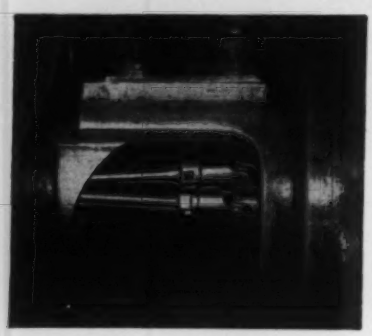
QUICK-LOCK • SPRING-LOCK • LINK-LOCK • HINGE-LOCK • ROTO-LOCK • DUAL-LOCK

Circle 546 on Page 19

Solving a breakage problem AT CLOSE QUARTERS



The manufacturer of this button-drilling machine had a tough problem: the universal joints on these parallel shafts carried such a torque load there were frequent complaints of breakage . . . yet the close centers prohibited use of a larger joint.

THE SOLUTION was a Curtis Universal Joint of the same size.

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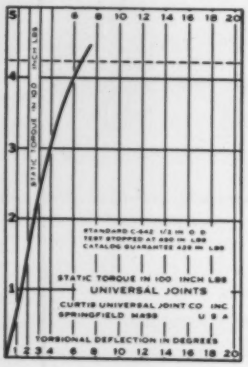
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Circle 547 on Page 19

topics include equilibrium diagrams, metallography, and thermal treatment of aluminum alloys, along with discussion of commercial aluminum casting alloys and commercial wrought aluminum alloys.

Power Reactors. *64 pages, 8½ by 11 in., paperbound; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $3.00 per copy.*

This is the first in a series of books containing design and construction data on reactors. Contents include general descriptions, power data, nuclear data, fuel elements and blankets, reactors, reactor controls, coolant systems and steam systems of 16 power reactors. Also included are schematic flow diagrams of the systems.

Basic Metallurgy. *Edited by G. William Zuspan; 232 pages, 6 by 9 in., clothbound; published by and available from American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; $7.50 per copy.*

This book, published as a companion volume to *Basic Metallurgy, Vol. I*, describes the various metal-testing procedures, equipment, and techniques. Supplementing the main text are graphs and charts containing metal characteristics and physical properties.

Symposium on Titanium. *214 pages, 6 by 9 in., hard cover; published by and available from American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.; $4.75 per copy.*

This book gives 14 papers presented at the Second Pacific Area National Meeting. The papers pertain primarily to properties evaluation of titanium and are designed to give technical information on which to base specifications.

Nondestructive Testing Symbols. *10 pages, 6 by 9 in., paperbound; published by and available from American Welding Society, 33 West 39th St., New York 18, N. Y.; $1.00 per copy.*

This standard sets up nondestructive testing symbols, which may be combined with welding symbols to specify complete welding and testing instructions in one character.

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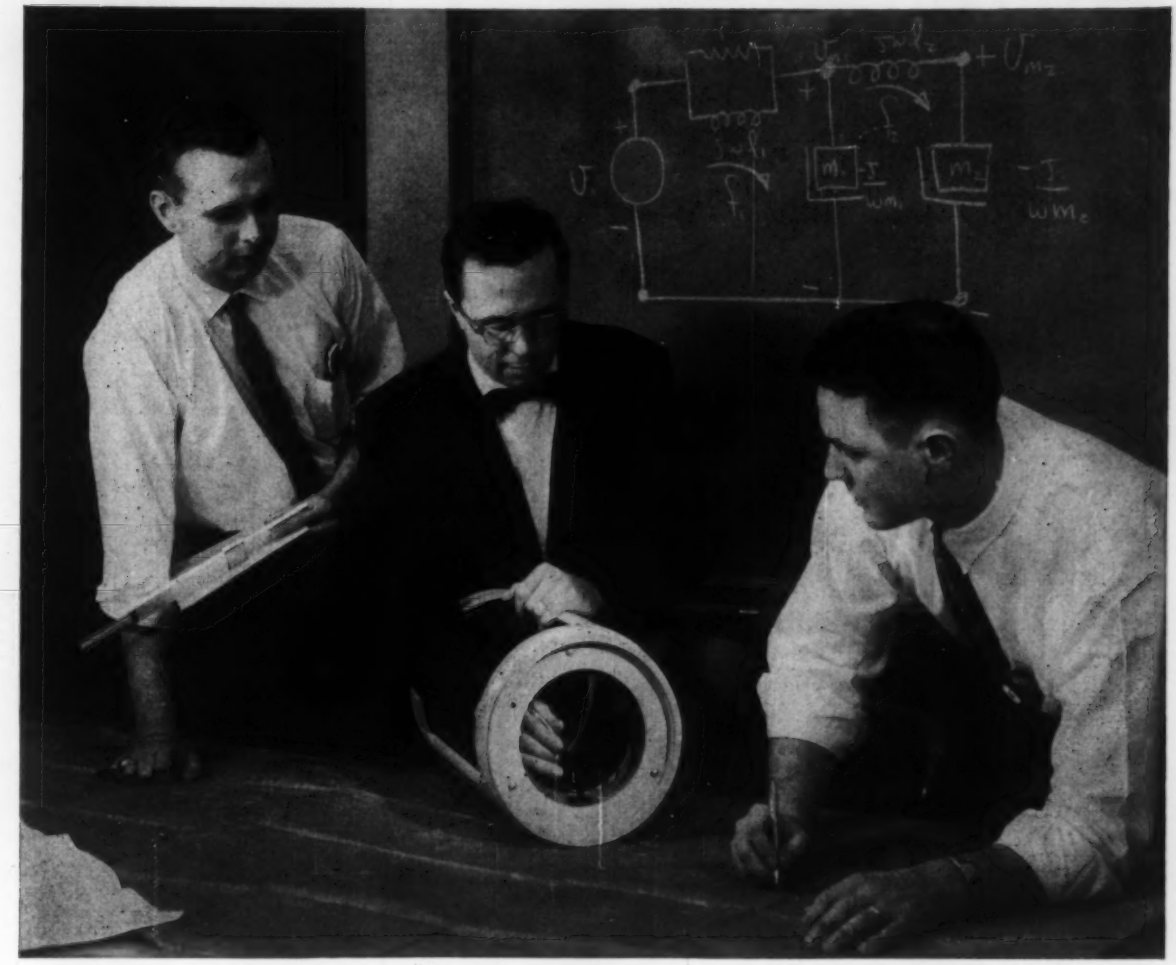

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Professional

. . . states of stress . . .

To the Editor:

Two papers entitled "States of Stress," by J. O. Predale (MACHINE DESIGN, June 13, 1957) and by E. W. Suppiger (MACHINE DESIGN, December 26, 1957), have both erred in the identical illustrative example. In both papers, in Example 2, the maximum shearing stress is given as −8000 psi. Both papers have considered the two-dimensional stress problem instead of a three-dimensional stress problem with the third principal stress being zero. The maximum shear stress is one-half the greatest difference of any two of the three principal stresses.

For the given data, $\sigma_{xp} = 20{,}000$; $\sigma_{yp} = 4000$. However, for the two-dimensional stress, $\sigma_{zp} = 0$. The three principal stresses are, therefore, 20,000, 4000, and 0. The fact that the third principal stress is zero cannot be overlooked or ignored.

The maximum shear stress at the point under consideration depends upon the largest value of $(20{,}000 - 4000)/2 = 8000$ psi, or $(20{,}000 - 0)/2 = 10{,}000$ psi, or $(4000 - 0)/2 = 2000$ psi.

Note that 10,000 psi is the maximum shear stress, not 8000 psi, as given in the two papers.

Even though the papers did not intend the problem to be a three-dimensional one, the omission of the consideration gives a misleading picture and an incorrect answer. The error is an extensive one in the literature, and the two papers have not contributed to the clarification.

—A. R. HOLOWENKO
—H. G. LAUGHLIN
Purdue University

To the Editor:

In my article, the stress field treated was unmistakably defined as two-dimensional, the stress components σ_x, σ_y, τ_{xy} being functions of x and y only, and $\tau_{xz} = \tau_{yz} = \sigma_z = 0$.

The two-dimensional nature of the transformation of stress at point 0 clearly implies that all planes associated with stresses must be taken perpendicular to the xy plane of reference; otherwise the hypothesis of the problem is contradicted. Thus, in particular, it is evident that the τ_{max} stress components are maximum with respect to planes perpendicular to the xy plane, and only for such planes. This is, of course, consistent with the two-dimensional definition of the problem.

It follows, therefore, that τ_{max} of −8000 psi determined in Example 2 is the maximum shearing stress with respect to planes perpendicular to the xy plane. Please note that the τ_{max} system of stresses corresponding to the value given by Professors Holowenko and Laughlin is quite different in nature from that defined in my article.

Viewpoints

Reference is made to the three-dimensional transformation of stress at a point which is quite incompatible with the premise of my article.

I should like to summarize my point by referring to just one authoritative source, *Kent's Mechanical Engineers' Handbook—Design and Production*, Twelfth Edition (John Wiley & Sons Inc., New York, 1950). On Page 8-44 one conventional method, which would yield the same result for τ_{max} as I obtained in Example 2, is clearly discussed. The treatment definitely implies without ambiguity that the τ_{max} components are acting on planes perpendicular to the xy plane, and thus the maximum property here is with respect to such planes only. Furthermore, it is not implied that τ_{max} is the absolute τ_{max} as viewed from a three-dimensional standpoint. This latter problem is treated in detail in the transformation of three-dimensional stress systems in books on the theory of elasticity.

—JOHN O. PREDALE
Newark College of Engineering

To the Editor:

The sole purpose of my short paper was to show how one may use the dyadic circle to solve the plane stress transformation equations.

The well-known book by S. Timoskenko and J. N. Goodier, *Theory of Elasticity* (McGraw-Hill Book Co., New York, 1951), covers the situation very well—Page 15 on the maximum shearing stress in the case of plane stress, and Page 218 on the maximum shearing stress in the three-dimensional case.

—E. W. SUPPIGER
Princeton University

They Say . . .

"Unfortunately, it is a habit of many designers, engineers, and others to be reluctant to disclose their lack of knowledge by consulting other people. This is a disastrous outlook, for one should be ready to acquire knowledge constantly throughout one's life for changes in theory and practice over a lifetime are very great. Those who do not keep themselves in touch with progress easily drop behind. The first essential to being able to keep up with the march of time and science is an intimate knowledge of basic principles. Engineers with a sound basic knowledge in mechanics are less hesitant to consult specialists in other fields, whereas those who have not this knowledge hesitate to consult other people for fear of revealing their ignorance." —SIR GEORGE H. NELSON, *president, Institute of Electrical Engineers.*

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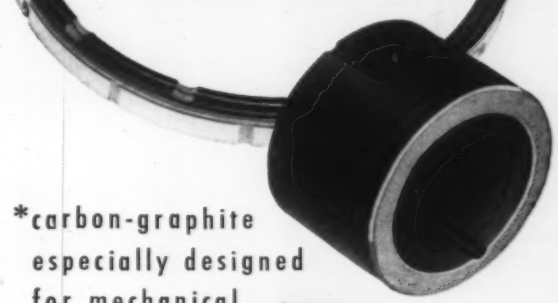

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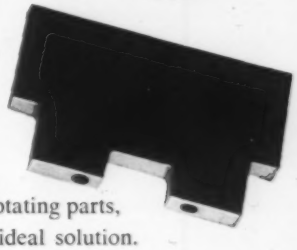

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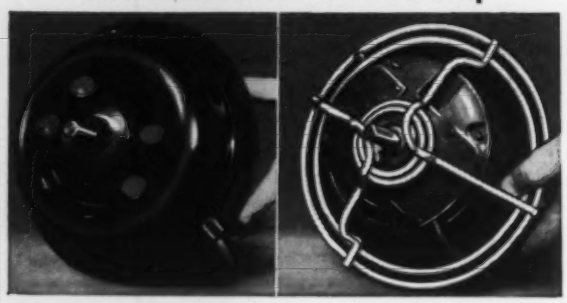

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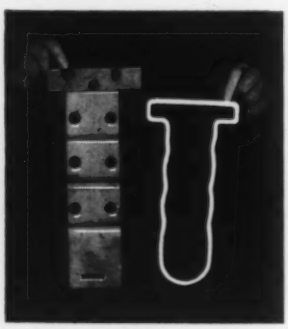

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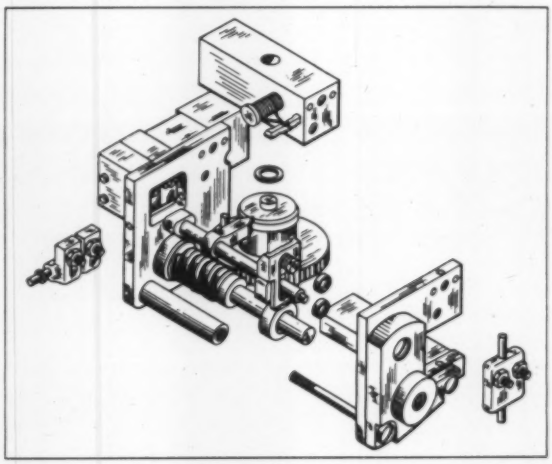
Patents

Rotary-Motion Memory

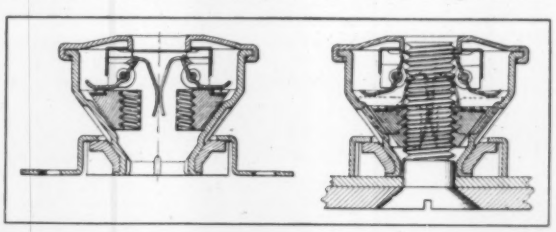
Revolutions of the input shaft of a rotary-motion memory unit are counted, stored, and subsequently delivered at the memory-unit output shaft. Typical



use is in conjunction with a revolution counter or similar totalizing device which continuously displays cumulative angular displacement of an input shaft. When it is necessary to interrupt operation of the totalizer for a short time without losing count of input information, the rotary-motion memory is used for temporary input-rotation storage. When operation of the totalizing counter resumes, information stored in the memory is fed into totalizer, giving a correct cumulative count. *Patent 2,806,571 assigned to General Precision Laboratory Inc. by Maurice I. Zeldman, Jackson Heights, N. Y.*

Quick-Acting Fastener

Partial turn of a standard bolt secures or releases a quick-acting blind nut designed for use on removable access doors and similar installations. Insertion of bolt initiates locking action by moving a pair of half-round tapered nuts into the reduced-diameter portion of the cylindrical shell. Fastener is fully secured when bolt is tightened. Springs in the fastener expel the bolt and return the split nuts to the large-diame-



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Circle 552 on Page 19

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This new AGASTAT time delay relay is an externally adjustable, double-pole, double-throw unit. It incorporates the basic AGASTAT timing principle, proved by a half-century of reliable operation on automatic aids to navigation, in a space-saving miniature unit, built to withstand the rugged environmental conditions of missile and aircraft applications.

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Circle 554 on Page 19

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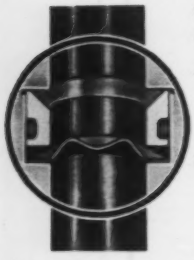

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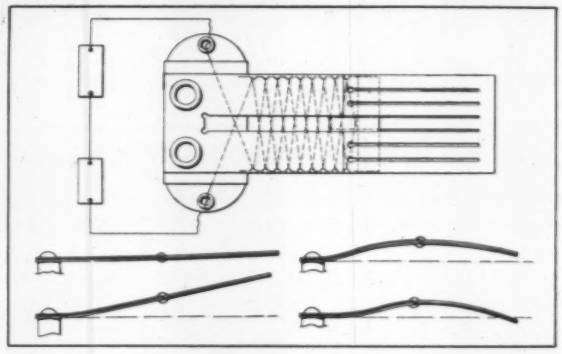
ter portion of the shell when the bolt is backed off a partial turn. *Patent* 2,814,324 *assigned to Waldes Kohinoor Inc., Long Island City, N. Y., by Ira Shur.*

Fast-Acting Bimetal Control

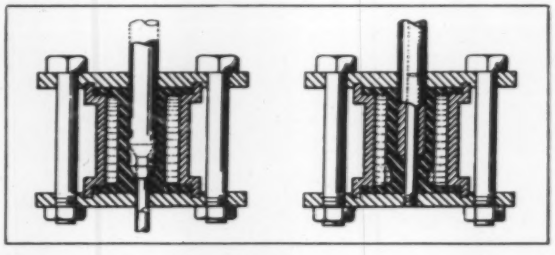
Bimetallic elements, inverted to deflect in opposite directions, are butt welded end to end to give fast response in a bimetallic heat motor. Innermost element is heated directly by a resistance winding; outermost



element is heated by conduction from the inner element. Cycle of operation, shown in detail sketches, is as follows: 1. Heater current off—both elements undeflected (upper left). 2. Heater current on—inner element deflecting, outer element undeflected (lower left). 3. Heater current continued—inner element deflecting up, outer element deflecting down (upper right). 4. Heater current off—inner element deflecting downward, tip of outer- element moves quickly past neutral axis (lower left). *Patent* 2,821,836 *assigned to D. H. McCorkle Co., Berkeley, Calif., by Donald H. McCorkle Sr.*

Heat Motor

Volume changes of an enclosed expansible mixture with high coefficient of thermal expansion provide the actuating force in a thermally actuated motor. When



heat is added, the mixture expands, compressing an elastic spool surrounding the heat-motor actuating rod. Resulting pressure on the tapered section of the rod forces it out of the spool. When the mixture is allowed to cool, the actuator rod can be returned by an external force. Typical use is in indicating or controlling temperatures. *Patent* 2,806,375 *assigned to Standard Thompson Corp., Dayton, Ohio, by Charles W. Wood.*

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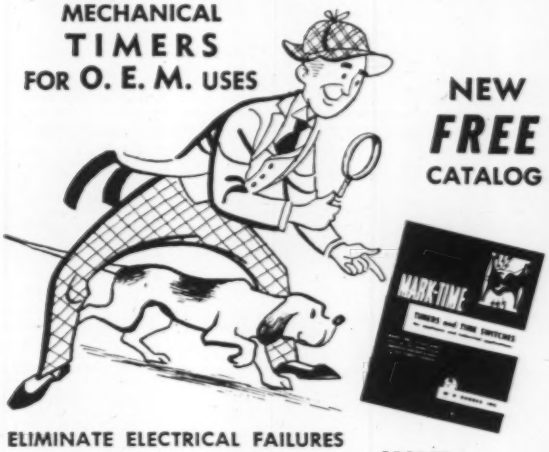
TIMERS
FOR O. E. M. USES



NEW
FREE
CATALOG

ELIMINATE ELECTRICAL FAILURES

Custom-built timers in small, medium or large quantities are our specialty. Over 3,000 **different** kinds of timers presently being produced. Timers can be designed to ring bells, flash lights, turn valves, cut cords, stop, start or operate electrical or mechanical equipment, etc. Timing ranges from seconds to hours. Unlimited uses for practically all products — all fields.

SECRET

Current use in guided missile program includes four major areas — TESTING, LAUNCHING, FIRING, RECOVERY. R. & D. work welcome.

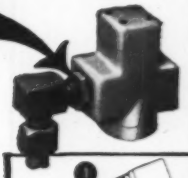
M. H. RHODES, INC. HARTFORD CONNECTICUT

Circle 556 on Page 19

TRU-SEAL

TEFLON SEAL

Saves hours in piping installations



PAT. PENDING

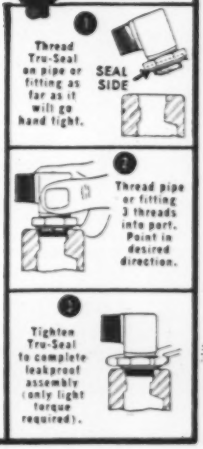
Eliminates leaks in oil, air, water, vacuum, chemical lines

Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

For further information write

TRU-SEAL DIVISION
FLICK-REEDY CORPORATION
2006 N. Hawthorne Melrose Park, Ill.

"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle 557 on Page 19

"MONOBALL" Self-Aligning Bearings

PATENTED U.S.A.
All World Rights Reserved

CHARACTERISTICS

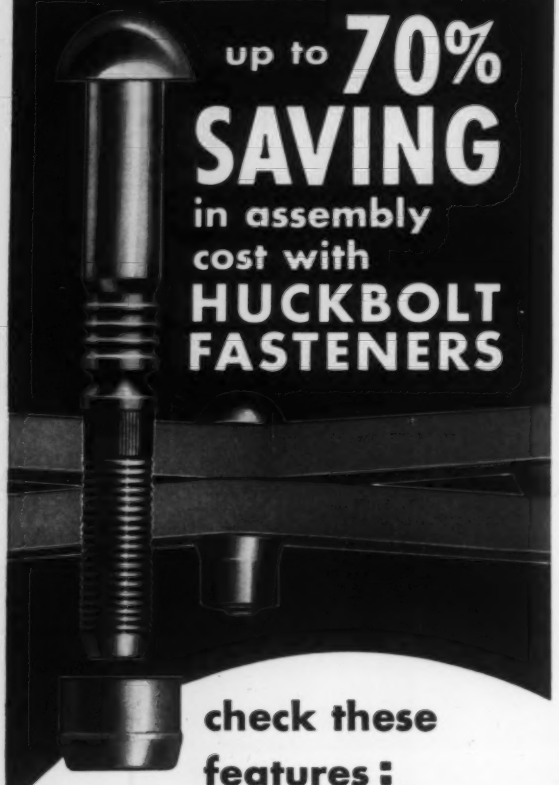
	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Alloy Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Alloy Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-58

SOUTHWEST PRODUCTS CO.
1705 SO. MOUNTAIN AVE., MONROVIA, CALIFORNIA

Circle 558 on Page 19

up to 70% SAVING in assembly cost with HUCKBOLT FASTENERS



check these features:

- High shear and tensile strength.
- Uniform high clinch and preload.
- Positive mechanical lock.
- Excellent sealing qualities.
- Fast, quiet installation.
- Low installed cost.
- Easy removal.
- Your choice of materials and head styles.

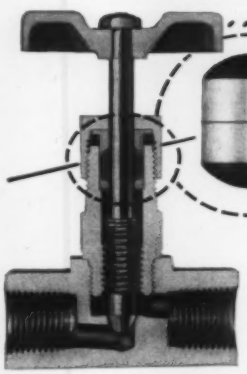
Huck fasteners offer you maximum uniform strength, high production, quiet application at advantageously low installed cost. There is a HUCK fastener to fill your need. Write for our condensed Commercial Catalog (No. 8-414) or a HUCK Fastener Consultant will call at your request.

HUCK MANUFACTURING COMPANY
2480 Bellevue Ave • Detroit 7, Mich.
Phone WAlnut 1-6207

Circle 559 on Page 19

"...yet we have IMPROVED it"

The Marsh Stainless Steel Needle Valve could have gone right on being the finest in its field...yet we have improved it



...with fabulous "TEFLON" packing

Note the "close-up." The Marsh Marpak packing system, originated in the Marsh Needle Valve, was one of the factors that has enabled it to stand up and work right under pressures up to 10,000 psi.

Now "Teflon" is used in this packing system—the miracle material of almost incredible *toughness, resilience* and *non-adhesive* properties...properties that are not impaired by the most powerful of solvents, acids, or alkalies even at temperatures *up to 500° F.*

Net result: The guaranteed application-range (up to 10,000 psi) is now effective at any temperature up to 500° F. (In other makes, permissible temperature decreases as pressure increases.)

Marsh Marpak Teflon Packing System is standard in Marsh 416 Stainless Steel Needle Throttling Valves. Ask for facts.

MARSH
Needle Valve in 416
stainless steel throughout
Now with "Teflon" Packing

MARSH INSTRUMENT CO. *Sales Affiliate of Jas. P. Marsh Corp.*, Dept B, Skokie, Ill.
Marsh Instrument and Valve Co. (Canada) Ltd., 8407 103rd St., Edmonton, Alberta
Houston Branch Plant: 1121 Rothwell St., Sect. 15, Houston, Texas

Circle 560 on Page 19

If GEARS Are YOUR Problem

We Can...

- act as your precision gear department
- keep your production line going smoothly without shut-downs
- reduce rejects, hand adjustments or other supervisory attention
- provide you with precise gearing for any purpose whatever
- and do it with a strict adherence to safe engineering economy

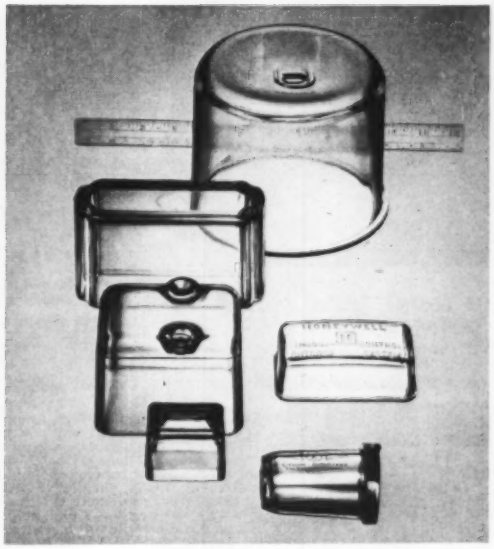
SPECIALISTS IN THE FINE PITCH FIELD

Use our more than a decade of experience in Gear making, in any material, for America's most particular users of precision or commercial gears. Send blueprints or specs for prompt estimates to

PG PROCESS GEAR CO., INC.
4608 W. Fullerton Ave • Chicago 39, Illinois

Circle 561 on Page 19

design flexibility in glass



Visibly protected by Lancaster!

Your delicate mechanisms deserve the complete protection and visibility that only glass covers can give. They permit close visual inspection with maximum safety.

Lancaster has formulae and facilities to meet your specific needs in limited as well as mass-produced quantities. Write today for complete details, or send blueprints for quotation to Lancaster Glass Corporation, Lancaster 2, Ohio.

Lancaster glass and plastics

to brighten your product's future . . .

Circle 562 on Page 19

NEW! air duct with highest flame and heat resistance

• A new flexible air duct, type 5J-1D, features high resistance to flame and temperature extremes. Originally designed for air conditioning systems, its heat resistant properties make it ideal for use where internal or ambient temperatures range from −40° to +350°F—as much as +450°F for short durations. In a severe test at 2000°F for four hours, fire was contained within the duct — and, although its tensile strength was reduced, the duct remained intact and prevented the fire from spreading. For details, send for Folder 591 and Data Sheet S-13.

Exclusive construction: The positive mechanical lock unites metal and fabric securely — guarantees long life.

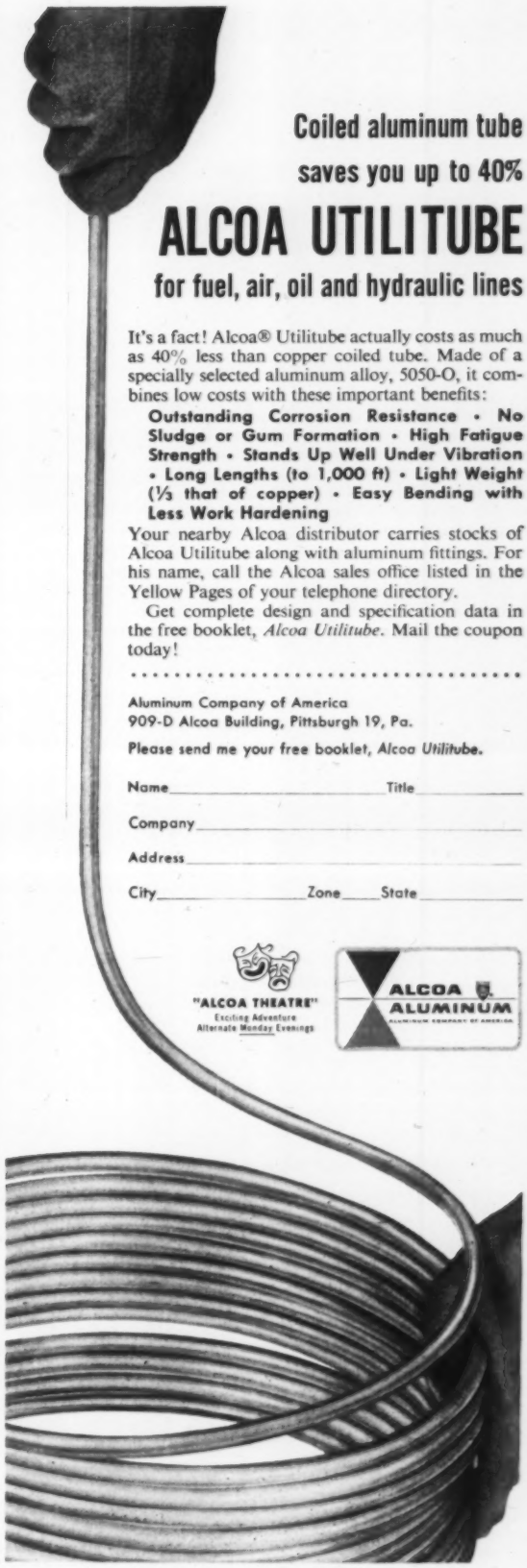
Wiremold flexible ducts for

air • dust • fumes • materials handling

WIREMOLD® FLEXIBLE AIR DUCT

THE WIREMOLD COMPANY, HARTFORD 10, CONNECTICUT

Circle 563 on Page 19



Coiled aluminum tube saves you up to 40%

ALCOA UTILITUBE

for fuel, air, oil and hydraulic lines

It's a fact! Alcoa® Utilitube actually costs as much as 40% less than copper coiled tube. Made of a specially selected aluminum alloy, 5050-O, it combines low costs with these important benefits:

Outstanding Corrosion Resistance • No Sludge or Gum Formation • High Fatigue Strength • Stands Up Well Under Vibration • Long Lengths (to 1,000 ft) • Light Weight (⅓ that of copper) • Easy Bending with Less Work Hardening

Your nearby Alcoa distributor carries stocks of Alcoa Utilitube along with aluminum fittings. For his name, call the Alcoa sales office listed in the Yellow Pages of your telephone directory.

Get complete design and specification data in the free booklet, *Alcoa Utilitube*. Mail the coupon today!

. . . . . .

Aluminum Company of America
909-D Alcoa Building, Pittsburgh 19, Pa.

Please send me your free booklet, *Alcoa Utilitube*.

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Company_____

Address_____

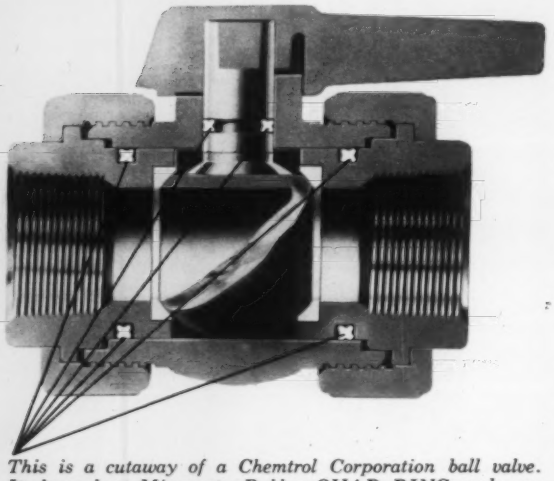
City_____ Zone____ State_____

"ALCOA THEATRE"
Exciting Adventure
Alternate Monday Evenings

ALCOA ALUMINUM

Circle 564 on Page 19

Why did CHEMTROL convert 100% to QUAD®RING seals?



This is a cutaway of a Chemtrol Corporation ball valve. It shows how Minnesota Rubber QUAD RING seals are used to maintain a bubble-tight seal from high vacuum to over 3000 psi.

O-rings have been completely replaced by exclusive Minnesota Rubber QUAD RING Seals in the complete line of needle valves, globe valves and ball valves manufactured by the Chemtrol Corporation in southern California.

Here is what Martin Usab, president of Chemtrol, wrote in explaining his decision:

"The most important factor is the ability of the QUAD RING type seals to maintain a bubble-tight seal ranging from high vacuum to our maximum pressures . . . to over 3000 psi.

"It has been our experience that the QUAD RING seal, due to its unique contact arrangement, has the ability to withstand more wear with less degradation than any other type of seal."

Mr. Usab also comments on the "unusually high dependability rate" of the unique Minnesota Rubber QUAD RING.

If you use rubber components in the items you produce, Minnesota Rubber can help you achieve better efficiency and dependability. One member of the Minnesota Rubber family is Research and Development Division, specifically set up to aid M-R customers in applied product development. Write for full information; also for 16-page facilities brochure.

MINNESOTA RUBBER

MINNESOTA RUBBER COMPANY

3630 Wooddale Ave., Minneapolis 16, Minn., Dept. 808

for color in rubber	Rainbow Rubber Division
for parts of silicone rubber	Silicone Rubber Division
for versatility in rubber	Plastic & Latex Division
for applied product development	Research & Development Division

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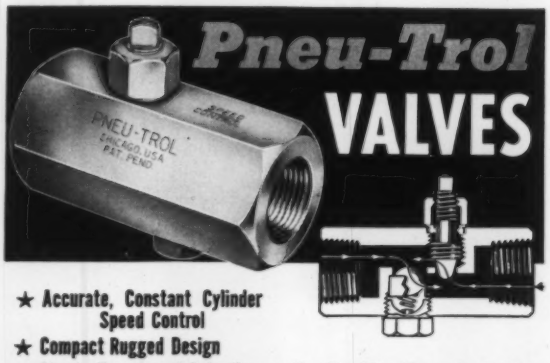
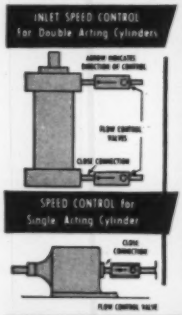
Pneu-Trol VALVES



★ Accurate, Constant Cylinder Speed Control
★ Compact Rugged Design
★ Simple, Easy Speed Selection ★ For Air, Oil or Water Applications



Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

Write for illustrated circular and prices.

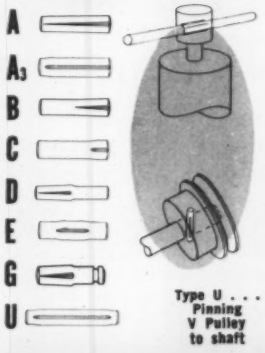
Pneu-Trol DEVICES, INC.

1436 N. KEATING AVENUE • CHICAGO 51, ILL.

Circle 566 on Page 19

REDUCE *costs...*
INCREASE *product quality...*
WITH
DRIV-LOK PINS

STANDARD TYPES



- **Fast installation . . . drill a hole and drive it in**
- **Greater holding power . . . once installed they *stay in***
- **Solid body . . . greater strength, better appearance**

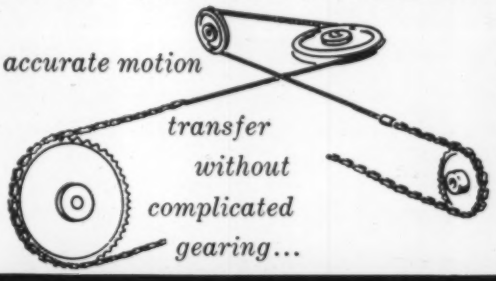
DRIV-LOK Grooved Fasteners have been proven in thousands of applications . . . are saving time and labor wherever they're used. 8 standard types—many specials. Wide variety of materials. Prompt deliveries, competitive prices. Write us, giving the nature of your fastening application. We'll recommend and send samples. No obligation, of course. Write for complete Driv-Lok Catalog

DRIV-LOK SALES CORPORATION

715 Park Avenue • Sycamore, Illinois

Circle 567 on Page 19

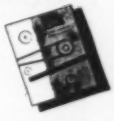
MORE DESIGN FREEDOM



SIERRA MINIATURE MECHANICAL CHAIN AND SPROCKETS...

Provide precise, positive motion transfer through several planes simultaneously with no cable slippage...no complicated gearing. Unlimited center-to-center selection for miniature and sub-miniature assemblies in servo systems, gyro systems, special cameras, electronic equipment, and small precision instruments. Less weight, cost, maintenance —wider tolerances. Designed to operate around minimum 7-tooth sprocket with root diameter of .250 inches. Chain pitch .1475 inches; Weight .45 oz. per lineal ft. Material: stainless steel, or other materials, including non-magnetic beryllium copper.

NEW CATALOG



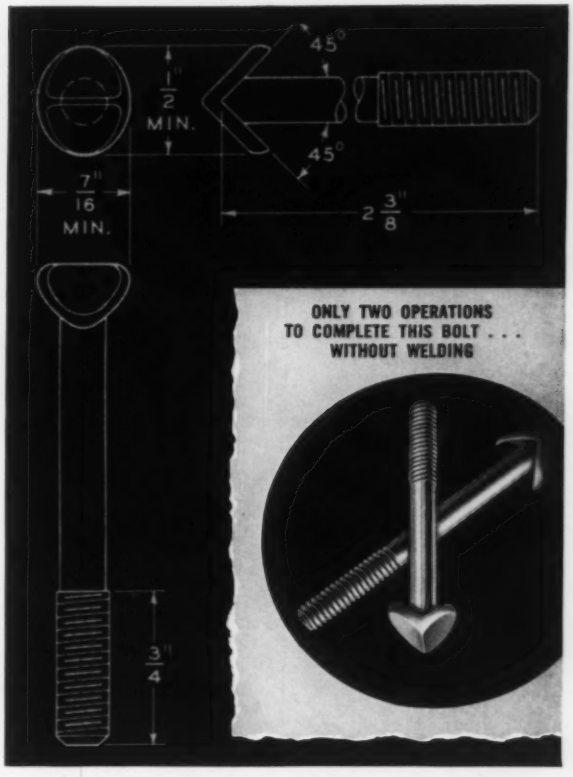
Contains useful application data, specifications, tables on chain pitch and sprocket sizes, suggestions for calculating center-to-center distance. *Write for yours today.*

123 E. Montecito Avenue, Sierra Madre, California

Sierra ENGINEERING CO.

T. M. REG.

Circle 568 on Page 19



made in one piece for less by cold heading

Functionally right for its purpose, this angle iron bolt would be expensive to produce by conventional methods. But Progressive made it by cold heading — the only practical way to produce the bolt in one piece. Only two operations—heading and threading—completed the bolt. Avoids a costly welding operation too.

You can make savings like this with Progressive cold heading—and get naturally stronger fasteners. Write for more case histories in our *"Bank Book of Savings in Cold Heading."*

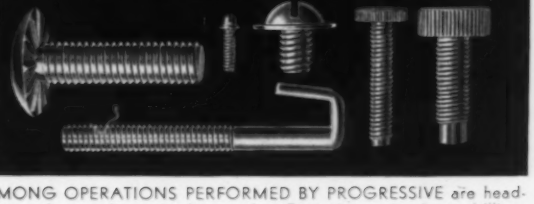
MACHINE SCREWS AND NUTS, SEMS FASTENERS, SLOTTED TAPPING SCREWS AND PHILLIPS HEAD SCREWS

THE PROGRESSIVE MFG. CO.

Division of The Torrington Company

52 Norwood St., Torrington, Connecticut

SAVE ON PARTS LIKE THESE



AMONG OPERATIONS PERFORMED BY PROGRESSIVE are heading and extruding simultaneously; flattening; piercing; drilling; bending; pointing; fluted or diamond knurling; trimming; turning tenons, shoulders or recesses; struck or sawed slotting; notching.

FREE SAMPLES and APPLICATIONS of INDUSTRIAL FELT*

*made to S.A.E. and Federal Govt. Specifications

See why **CONTINENTAL FELT** fills hundreds of jobs daily

SEE HOW FELT FITS IN WITH YOUR PRODUCTS

Ask for booklet M-12

CONTINENTAL **FELT** COMPANY, INC. 1905

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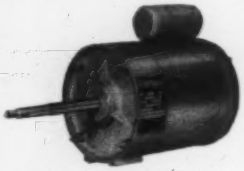
Circle 570 on Page 19

SELECTING MOTORS... for Original Equipment Applications

NEMA "D" FLANGE

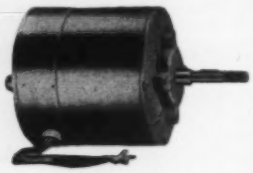
SPACE-SAVER TYPE MOTOR

EXPLOSION-PROOF TORQUE MOTOR WITH BRAKE



SPECIAL FLANGE REVERSING HOIST MOTOR SINGLE PHASE

WEATHER-TIGHT SPECIAL FLANGE



NAVY MOTOR SPRAY-TIGHT

Design your product to do a job, and Peerless will match a motor to it. There are hundreds of modified standards as well as really different specials in the Peerless files ... one that's operating on the bottom of the sea ... another on an underwater television camera ... still another driving a pump that handles atomic wastes.

These motors are a result of Peerless teamwork engineering—our working with you and your design engineers. Go ahead with your new design or development. Let your imagination run wild. When you're ready for power—see the Peerless representative nearest you or call us directly. We'll work with you to develop the motor that powers your product best.

ELECTRIC MOTOR DIVISION

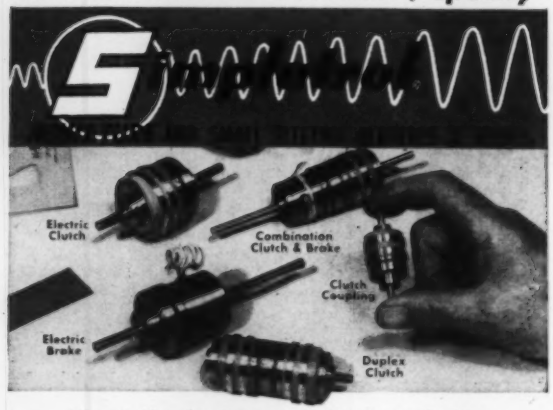
THE *Peerless-Electric*® COMPANY

FANS • BLOWERS • MOTORS

1520 W. MARKET ST. • WARREN, OHIO

Circle 571 on Page 19

for AUTOMATED CONTROL, specify



Check the features of this new design:

- Rapid diaphragm action, no sliding parts
- Precise clutching and braking – adjustable "soft" to "harsh" action
- Simplicity in design, trouble-free operation
- Silent action, eliminates magnetization of surrounding parts
- 5 standard styles; full range of sizes — 7/8" to 3 1/8" diameter

Check your requirements for electric clutch and brake control. You'll find SIMPLATROL Miniature and Small Electric Clutches and Brakes upgrade new machine performance, give faster, more precise sequence operations.

Ask for recommendations on Simplatrol units. New illustrated folder on request.

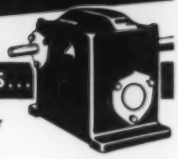
Simplatrol products corp.

24-5 SALISBURY ST., WORCESTER, MASS.

Representatives in Key Industrial Areas

Circle 572 on Page 19

Abart Specializes in a complete line of Speed Reducers and Gears



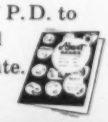
PRECISION-BUILT SPEED REDUCERS...

Over 75 types and sizes for any speed reduction need. Spiral, worm, combinations ... single and double reductions. Over 75 types and sizes—1/50 to over 400 hp. Ratios to 10,000 to 1.

Request Abart Speed Reducer Catalog

CUSTOM-CUT GEARS...

No stocks. Spur, spiral, bevel, helical, internal, worm, rack, sprocket —cut to your exact specifications. Any quantity, any material ... 5/7 D.P. to 96 D.P.—1/4" P.D. to 18" P.D. Send b.p. and specs or sample for estimate.



Request Abart Gear Bulletin

ABART GEAR and MACHINE CO.

4821 WEST 16th STREET • CHICAGO 50, ILLINOIS

Circle 573 on Page 19

DESIGN SECRETS EXPOSED

Over 15,000 engineers have chuckled their way through "Murder in the Model Shop". Now in its second big printing, this free 48-page pocket book tells in true Mickey Spillane style how an "engineer-private eye" solves actual servosystem and instrument design problems with SERVOBOARD® Electromechanical Assembly Kits. Appendix includes descriptions of servo components and kits, Servoscope® servosystem analyzer, and Servomation® building blocks.

For your copy write to:

SERVO CORPORATION OF AMERICA
20-32 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Circle 574 on Page 19

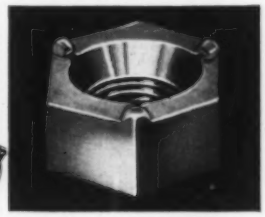
These 2 WELD NUTS *for blind assemblies*

will give you

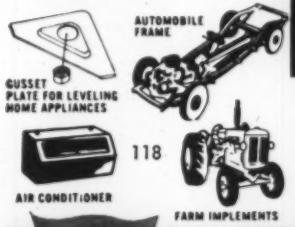
- **Easier Positioning**
- **Quicker Fastening**
- **Extra Threaded Depth**
- **Less Cost**

Available with or without Gripco locking feature. Three weld projections on bottom of nut provide a firm non-rocking electrical connection during welding. Write for samples and NEW CATALOG today.

Gripco Pilot-Projection Weld Nut, circular pilot designed, provides quick, easy positioning of nut in bolt hole for instant resistant welding. No jigs, no fumbling, no waste of time. Weld spatter cannot foul threads. Two pilot heights for different metal gauges.



Gripco Countersunk Weld Nut eliminates time-wasting retapping of nuts after welding. Exclusive countersunk nut bottom eliminates fouling of threads by weld spatter. No time wasting false starts, no cleaning of damaged threads, nut ready to receive bolt immediately.



GRIP NUT COMPANY
103 Maple Ave. • South Whitley, Ind.

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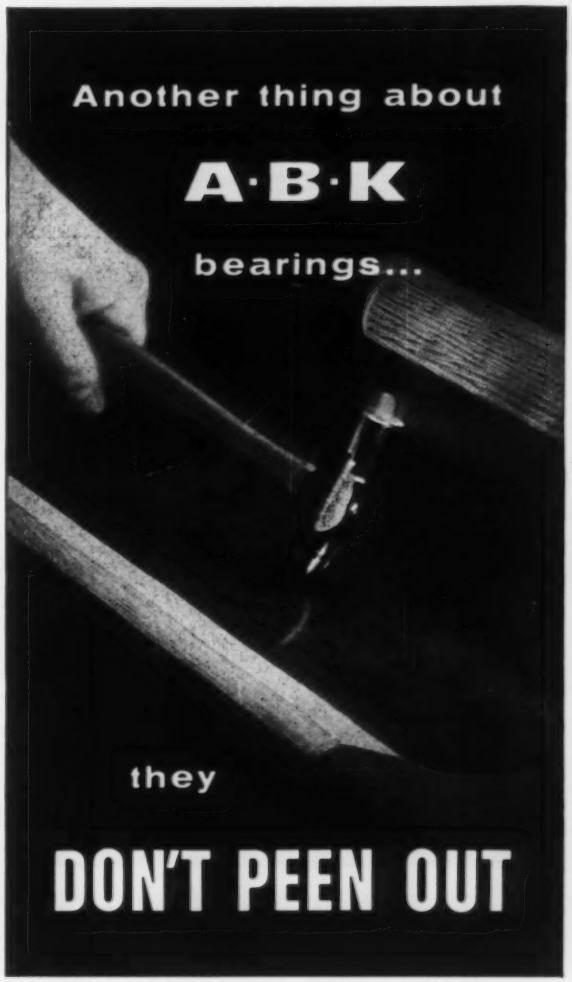

A·B·K — the bearing material of 1001 uses

The unusual properties of A-B-K Laminated Phenolic Bearings have helped engineers in widely divergent fields solve some of their toughest bearing problems.

It can be formed, machined to intricate shapes. It can be bonded to metal. It can be lubricated with water or oil. It often performs better, lasts longer than metal.

If you have a wear problem involving impact, strain or stress, friction, heat, chemical action or strength, write for our brochure, or state your requirements.

PROVED PROPERTIES

- Won't peen out
- High strength/weight ratio
- Resistance to acid, alkali, heat, abrasion
- High compression strength
- Perfect weathering
- Good machining
- Dimensional stability
- Slow, uniform wear
- Water or oil lubricated

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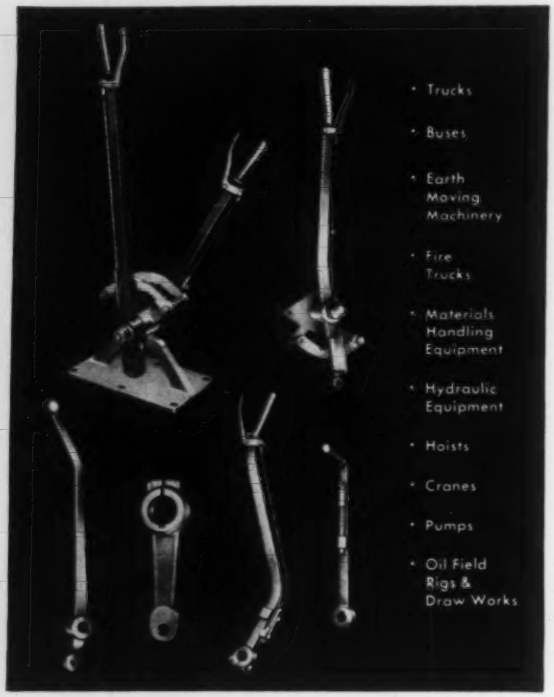

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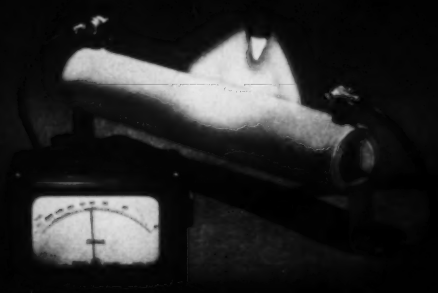

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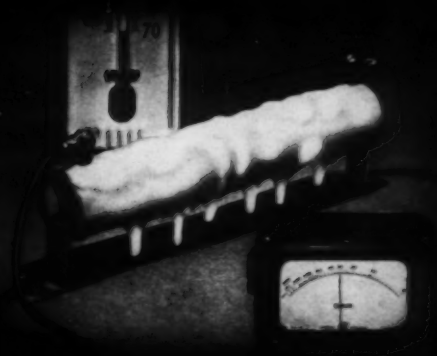

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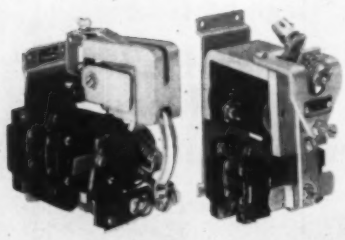

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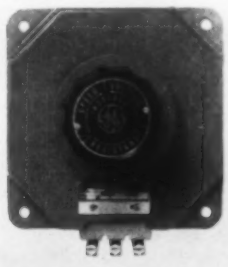

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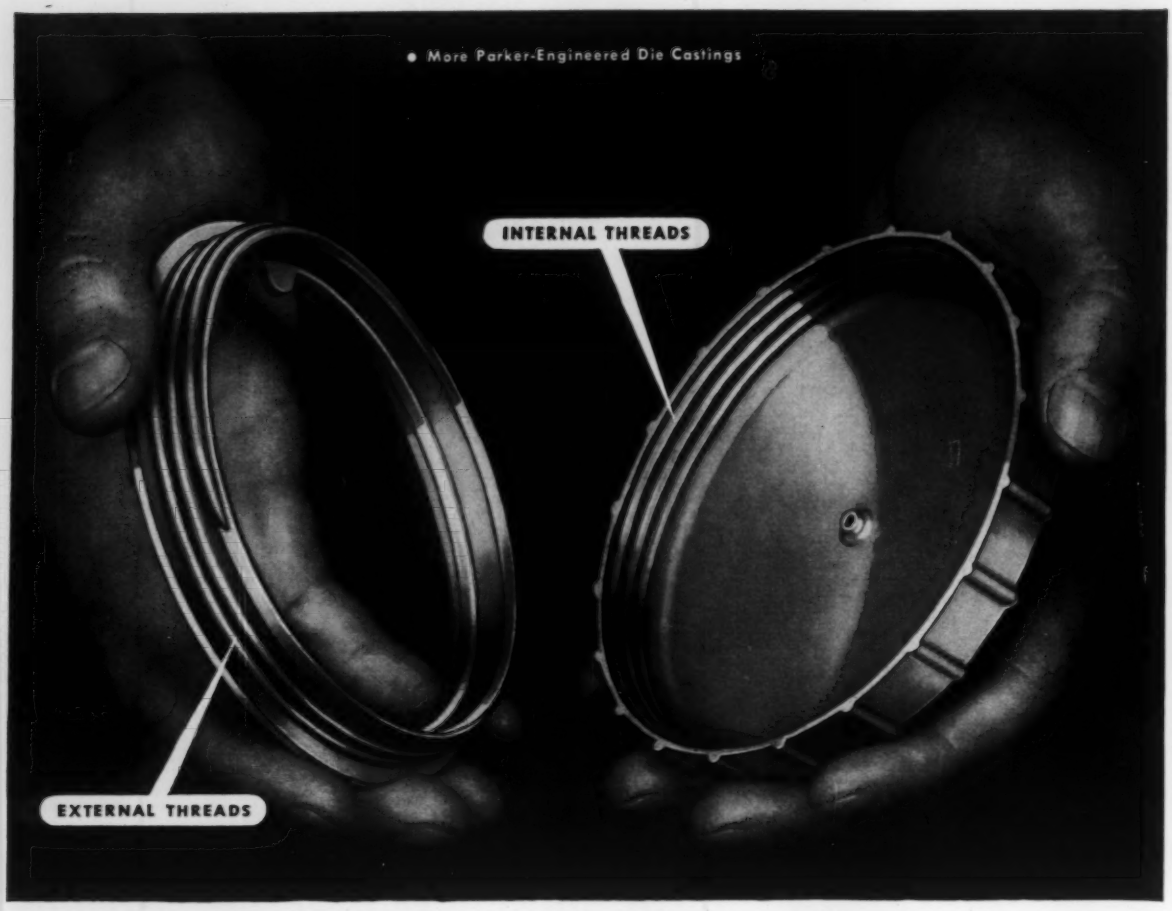

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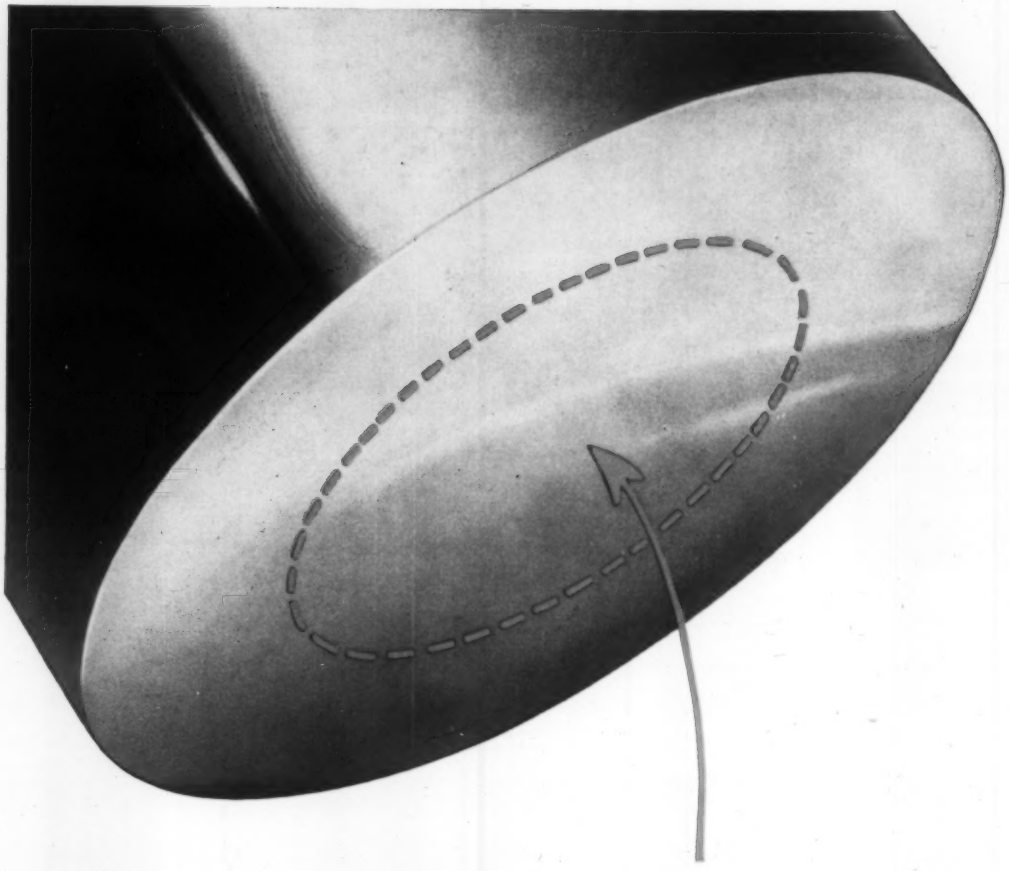

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